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NATIONAL DAM INSPECTION PROGRAM. CABIN CREEK DAM (NDS I.D. PA-0--ETC(U)
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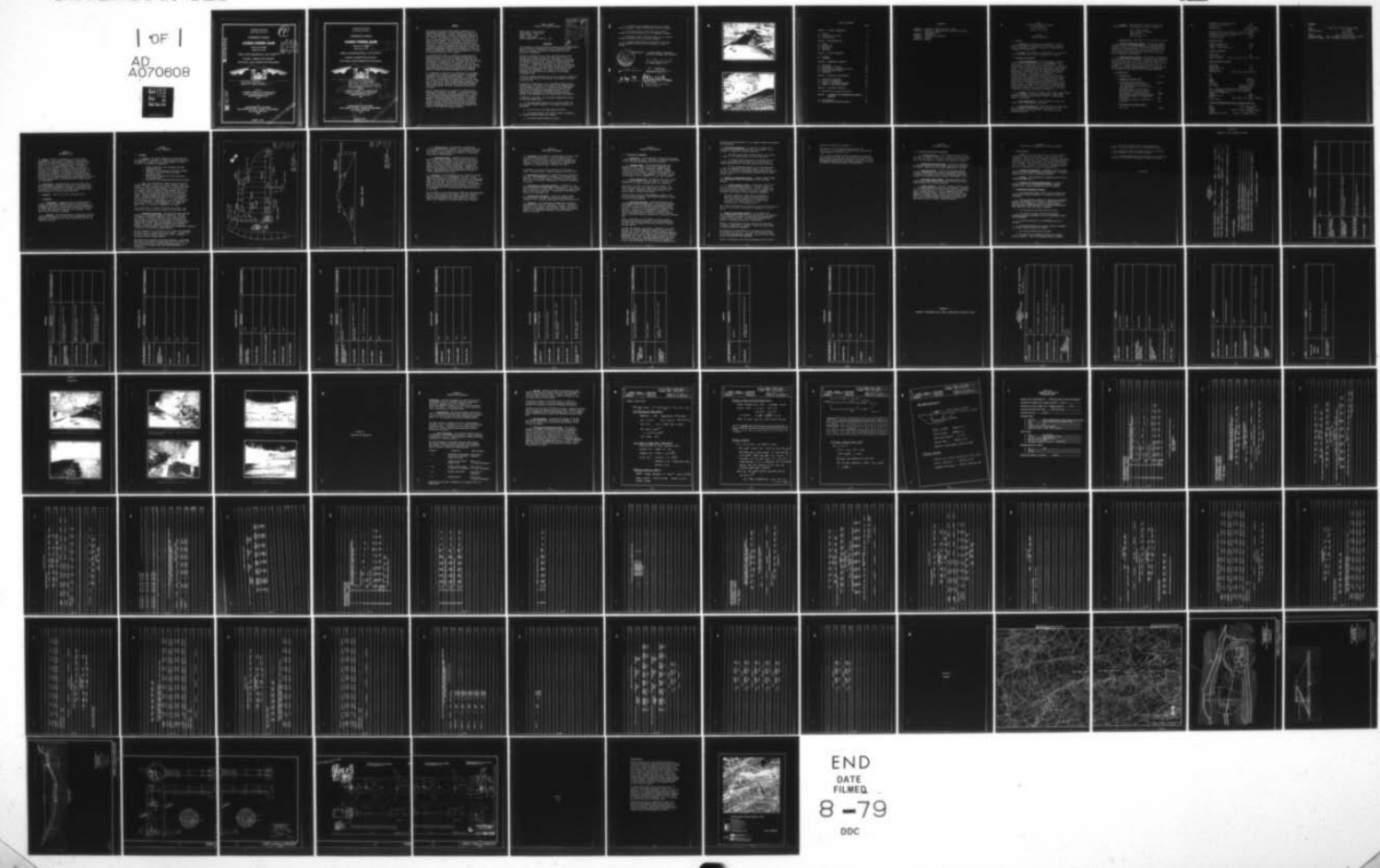

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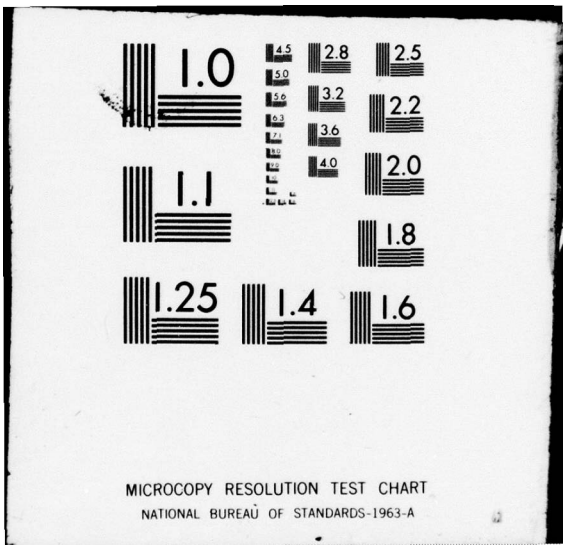
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SUSQUEHANNA RIVER BASIN

CABIN CREEK, YORK COUNTY

PENNSYLVANIA

CABIN CREEK DAM

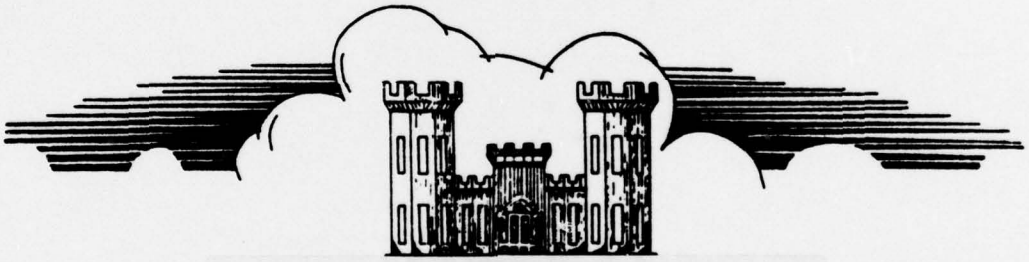
NDS ID NO. PA-00336

DER ID NO. 67-459

RED LION MUNICIPAL AUTHORITY

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM



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Prepared by

L. ROBERT KIMBALL and ASSOCIATES
CONSULTING ENGINEERS and ARCHITECTS
EBENSBURG, PENNSYLVANIA
15931

For

DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT CORPS OF ENGINEERS
BALTIMORE, MARYLAND
21203

MARCH 1979

SUSQUEHANNA RIVER BASIN

CABIN CREEK, YORK COUNTY

PENNSYLVANIA

CABIN CREEK DAM

NDS ID NO. PA-00336

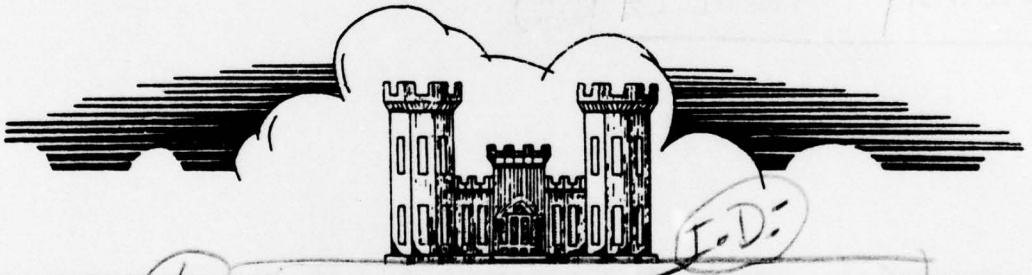
DER ID NO. 67-459

(10) R. Jeffrey Kimball, Kuang-hwei Chuang

RED LION MUNICIPAL AUTHORITY

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM



(6) National Dam Inspection Program. Cabin Creek Dam (NDS-PA-00336, DER-67-459), Susquehanna River Basin, Cabin Creek, York County, Pennsylvania, Red Lion Municipal Authority. Phase I Inspection Report.

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15931

(12) 95p.

(15) DACW31-79-C-0009

For

DEPARTMENT OF THE ARMY

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BALTIMORE, MARYLAND

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(11)

4/17059

MARCH 1979

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through frequent inspections can unsafe conditions be detected and only through continued care and maintenance can these conditions be prevented or corrected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the spillway design flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. The spillway design flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

PHASE I REPORT
NATIONAL DAM INSPECTION REPORT

NAME OF DAM: Cabin Creek Dam
STATE LOCATED: Pennsylvania
COUNTY LOCATED: York
STREAM: Cabin Creek
DATE OF INSPECTION: October 31, 1978

ASSESSMENT

The assessment of Cabin Creek Dam is based upon visual observations made at the time of inspection, review of available records and data, hydrologic and hydraulic computations, and past operational performance.

The dam is considered to be in fair condition because of the seepage and wet zones, erosion, and large trees at the toe. The existing spillway and reservoir are capable of controlling approximately 18% of the PMF. Based upon criteria established by the Corps of Engineers, the spillway is termed seriously inadequate. If Cabin Creek Dam should fail due to overtopping, the hazard to loss of life and property downstream from the dam would be significantly increased from that which would exist just prior to overtopping. As a result of the seriously inadequate spillway the dam is considered to be an unsafe non-emergency dam.

Studies and remedial modifications should be conducted immediately to increase the ability of the spillway and reservoir to safely control the PMF.

The absence of design data, the 2:1 downstream slopes and the seepage noted 8 feet above the toe make the long range stability of the embankment uncertain. An evaluation of the embankment stability using current criteria should be performed in the near future to substantiate embankment stability. Future studies should be directed at locating and monitoring the seepage in the embankment with the installation of piezometers.

In addition to the above, the following recommendations should be instituted immediately:

1. The owner should monitor the wet areas and seeps and take necessary remedial measures if the seeps are found to be increasing.

2. All low areas on the crest should be filled.

3. A detailed geologic study should be made to determine if a seismic stability analysis is needed.

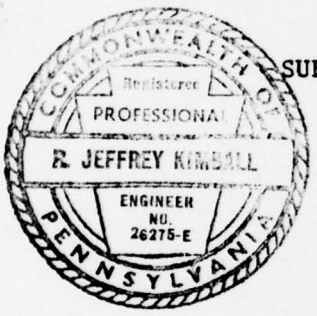
4. All erosion gullies should be filled.

5. The debris in the emergency spillway exit channel should be removed. Trees on the highwall should be removed.

6. Silt from the lower intake tower gate should be removed so that the intake can act as an emergency drawdown.

7. Institute a formal inspection program to be conducted at regular intervals with the borough's engineer.

8. A warning system should be instituted to warn downstream residents of high spillway discharges or failure of the dam.



SUBMITTED BY: L. ROBERT KIMBALL & ASSOCIATES
CONSULTING ENGINEERS AND ARCHITECTS

R. Jeffrey Kimball

R. Jeffrey Kimball, P.E.

3-16-79

Date

K. Chuang

Kuang-hwei Chuang, P.E.

10 Apr 79

Date

G. K. WITHERS
Colonel, Corps of Engineers
District Engineer

Overview of crest from right abutment.

Downstream slope from left abutment.

TABLE OF CONTENTS

APPENDICES

PHASE I
NATIONAL DAM INSPECTION PROGRAM
CABIN CREEK DAM
NDI I.D. NO. PA 336
DER I.D. NO. 67-459

SECTION 1
PROJECT INFORMATION

1.1 General.

a. Authority. The National Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of inspecting dams throughout the United States.

b. Purpose. The purpose of the inspection is to determine if the dam constitutes a hazard to human life or property.

1.2 Description of Project.

a. Dam and Appurtenances. Cabin Creek Dam is an earth-fill dam with a concrete core wall. The embankment is 207 feet long and 23.2 feet high at the maximum section. The upstream slope is 2.25H:1V and covered with riprap. The downstream slope is 2H:1V and grass covered with large trees growing near the toe. The 18 inch wide core wall extends 2 feet into rock and projects 5 feet above rock. The foundation was grouted during construction. The spillway is located on the left abutment. The spillway consists of a 30 feet long concrete weir with a hydraulically operated Bascule crest gate. The spillway exit channel is cut into rock with a dry rubble, earth and rock dike keeping flow in a confined channel. The intake tower is located near the maximum section about 40 feet from the crest. A bridge serves as access from the embankment crest to the intake tower. A 12 inch cast iron pipe serves as the emergency blow off line and water intake line. The intake tower has two intakes at different elevations.

b. Location. The dam is located on Cabin Creek, approximately 3.1 miles northeast of Red Lion, Pennsylvania. Cabin Creek Dam can be located on the Red Lion, U.S.G.S. 7.5 minute quadrangle in York County.

c. Size Classification. Cabin Creek Dam is a small size structure (23.2 feet high, 180 acre-feet).

d. Hazard Classification. Cabin Creek Dam is a high hazard dam. Downstream conditions indicate that loss of life is probable should the structure fail. See section 3.1e for downstream exposure.

e. Ownership. Cabin Creek Dam is owned by the Red Lion Municipal Authority. Correspondence should be addressed to:

Carl E. Seitz, Manager
Red Lion Municipal Authority
Center Square
Red Lion, PA 17356
(717) 244-3475

f. Purpose of Dam. Water supply for the Borough of Red Lion.

g. Design and Construction History. The dam was designed by Gannett, Seelye and Fleming Engineers, Inc. and construction completed in 1925. In June 1972, the dam was overtopped causing erosion on the downstream slope. In July 1972, the erosion was repaired and a porous tile drain installed near the toe. In 1973 a hydraulically operated bascule crest gate was installed and the flashboard system removed.

1. Normal Operating Procedure. The reservoir is maintained at the spillway crest elevation with the excess inflow discharging over the spillway crest. Water for the municipal water system enters the intake tower and 12 inch CI pipe. The flow in the pipe is regulated by valves in the filtration plant near the toe. An average of 1.7 million gallons per day of water is used. In addition to the normal inflow, approximately 1 million gallons per day is pumped into the reservoir from an adjacent watershed.

1.3 Pertinent Data.

a. Drainage Area. 2.63 sq.mi.

b. Discharge at Dam Site (cfs).

Maximum known flood at dam site (Dam overtopped in 1972) spillway at that time had smaller capacity than at the present time	Unknown
Warm water outlet at pool elevation	N/A
Drainage facilities low pool outlet at pool elevation - Inlet silted shut	None
Gated spillway capacity at pool elevation	N/A
Gated spillway capacity at maximum pool elevation	2055
Total spillway capacity at maximum pool elevation	2055

c. Elevation(U.S.G.S. Datum) (Feet).

Top of dam	595.0

Maximum pool - design surcharge	596.0
Full flood control pool	N/A
Normal pool	594.0 (normal)
Spillway crest	589.0 Open full
	594.0 Gate closed
Upstream portal invert drainage facilities	Unknown
Downstream portal invert drainage facilities	Unknown
Streambed at centerline of dam	573.0
Maximum tailwater	None

d. Reservoir (feet).

Length of maximum pool	2,500
Length of normal pool	1,700
Length of flood control pool	N/A

e. Storage (acre-feet).

Normal pool	178
Flood control pool	N/A
Design surcharge	208 at elevation 596.0 - Top of dam

f. Reservoir Surface (acres).

Top of dam	17
Maximum pool	17
Flood control pool	N/A
Normal pool	13
Spillway crest	10 gate open - elevation 589.0

g. Dam.

Type	Earthfill
Length	207 feet
Height	23.2 feet
Top width	15 feet
Side slopes	Upstream 2.5H:1V
	Downstream 2H:1V

Note: Construction drawings show below elevation 585 slope changes to 2.5H to 1V. Not observable during field inspection.

Zoning	None
Impervious core	None
Cutoff	Yes-concrete core wall at foundation
Grout curtain	Yes

h. Diversion and Regulating Tunnel - Drainage Facilities.

Type	12 inch cast iron pipe
Length	Unknown
Closure	Valve in intake tower in reservoir
Access	None
Regulating facilities	Valves in treatment facility

i. Spillway.

Type	Bascule gate controlled-open channel
Length	30 feet
Crest Elevation	589.0 open
	594.0 closed
Gates	Yes - 1 Bascule gate
Upstream channel	Lake - entrance formed by hillside & wingwall
Downstream channel	Rock cut channel to natural stream

SECTION 2
ENGINEERING DATA

2.1 Design. Review of information in the files of the Commonwealth of Pennsylvania, Department of Environmental Resources (Penn DER) and Red Lion Municipal Authority files, showed that very little engineering data is available for review of the structure's original design. The information available consisted of several original construction drawings. One drawing is available on the Bascule gate. No calculations or summaries are available on the stability or hydrology and hydraulics. The original specifications and specifications on the Bascule gate are in the Penn DER files. Penn DER files contained considerable correspondence particularly on permits, repairs made to the spillway, and in regard to the 1972 overtopping.

2.2 Construction. Construction data of the original dam is limited to several photographs taken during the construction and a memorandum discussing the grouting. Construction specifications are available on the original dam and Bascule gate. This information is located in Penn DER files.

2.3 Operation. There are no formal operating records.

2.4 Evaluation.

a. Availability. Engineering data was provided by the Division of Dam and Encroachments, Bureau of Water Quality Management, Department of Environmental Resources, Commonwealth of Pennsylvania and by the owner, Red Lion Municipal Authority. The owner made available the manager, his assistant, a caretaker, and the Authority's engineer.

b. Adequacy. The type and amount of design data and other engineering information is limited, and the assessment must be based upon the available data, visual inspection, history, and hydrologic analysis.

SECTION 3
VISUAL INSPECTION

3.1 Findings.

a. General. The onsite inspection of Cabin Creek Dam was conducted by personnel of L. Robert Kimball and Associates accompanied by borough staff and their engineer on October 21, 1978. The inspection consisted of:

1. Visual inspection of the retaining structure, abutments and toe.
2. Examination of the spillway facilities, exposed portions of any outlet works, and other appurtenant works.
3. Observations affecting the runoff potential of the drainage basin.
4. Evaluation of the downstream area hazard potential.

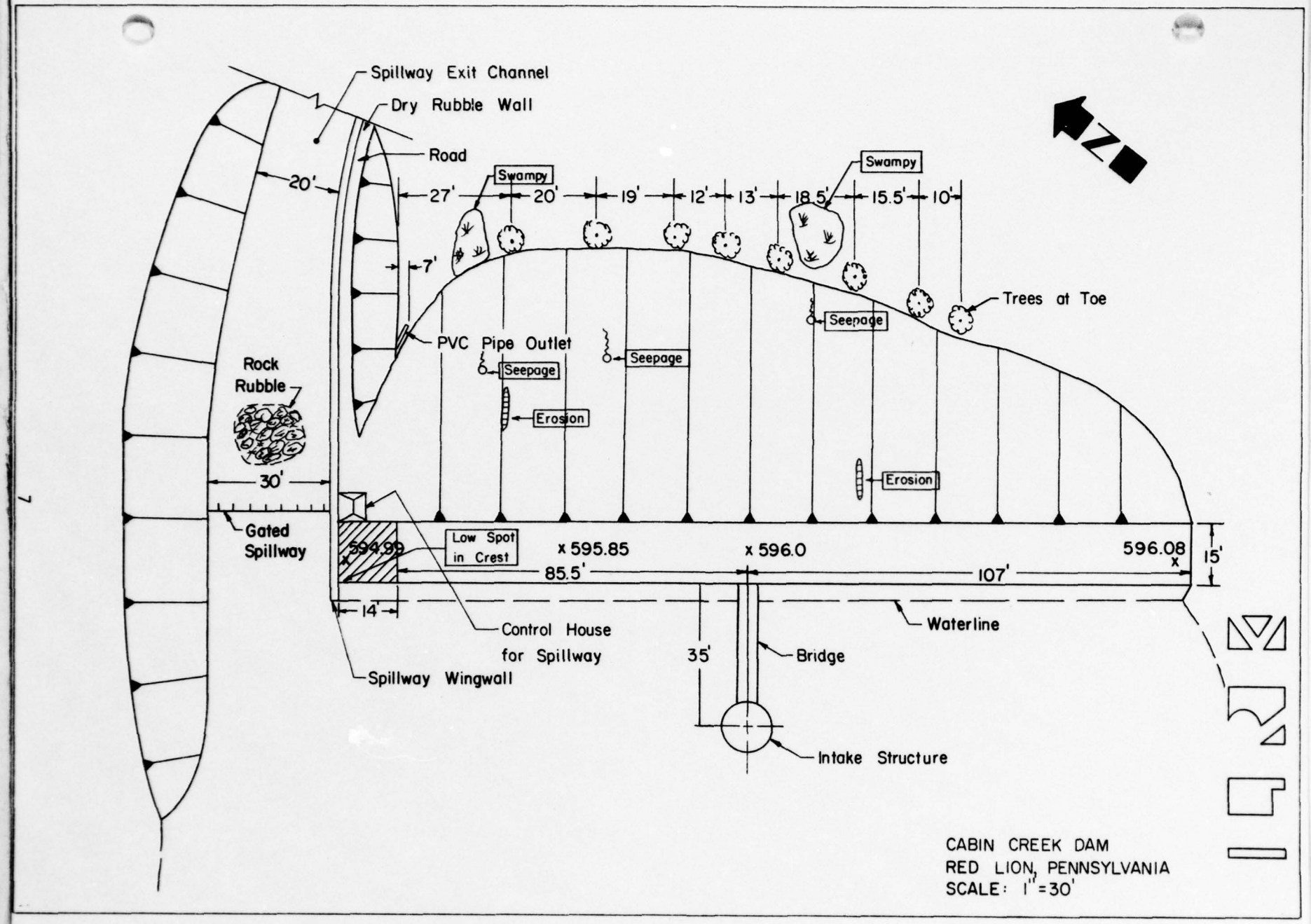
b. Dam. The dam appears to conform closely to the construction drawings. From a brief survey conducted during the inspection it was determined that several low spots are present on the crest toward the left abutment. One area adjacent to the emergency spillway wingwall is approximately one (1) foot low. Several erosion gullies were noted on the downstream slope. These gullies may have resulted from the 1972 overtopping. Several seepage zones were noted on the downstream slope. The seepage zones were small (2' x 2') and minimal flow was noted. Two (2) wet areas (6' x 6') were noted at the toe of the embankment. Approximately seven (7) large trees are growing at the toe of the embankment. See drawing on pages 7 and 8 for location of seepage and wet areas.

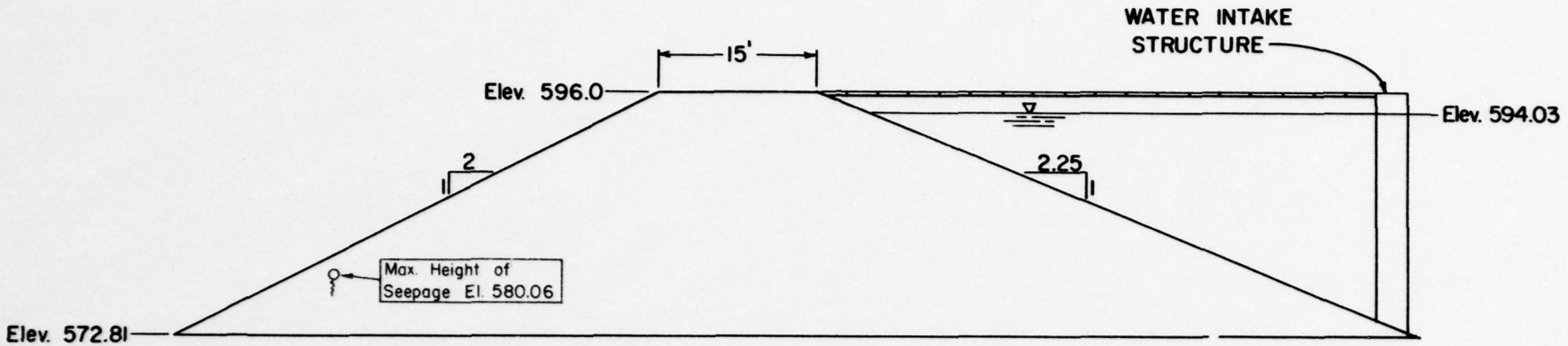
The upstream slope is covered with hand placed riprap. The downstream slope and crest are grassed which has been mowed.

c. Appurtenant Structures. The Bascule gate was operated manually by the caretaker during the inspection. The gate is designed to operate automatically with 6 inches of water over the top of the gate. When the water level reaches 12" over the gate the gate shall be fully open. For water levels between 6-12" the gate shall be positioned so as to maintain a constant water level. The gate is hydraulically operated. There is a standby generator at the dam for use during power failures. In addition, the gate can be opened manually.

The exit channel is cut in rock with a dry rubble rock embankment acting as a dike to confine flow to the channel. A recent rock fall has created a partial obstruction to flow. Trees are growing on the exit channel highwall.

The intake tower appeared to be in good condition. The intake gates and 12 inch cast iron supply line were not observed. The 12 inch pipe runs directly into the filtration plant. It is reported by the caretaker that the bottom intake gate is silted shut.


Spillway Exit Channel
Dry Rubble Wall
Road
20'
27'
Swampy
20'
19'
12'
13'
18.5'
Swampy
15.5'
10'
7'
Trees at Toe
Seepage
PVC Pipe Outlet
Seepage
Seepage
Rock Rubble
Erosion
Erosion
30'
Gated Spillway
Low Spot in Crest
394.99
x 595.85
x 596.0
596.08
x
15'
85.5'
107'
14'
Control House for Spillway
Waterline
35'
Bridge
Spillway Wingwall
Intake Structure
N
CABIN CREEK DAM
RED LION, PENNSYLVANIA
SCALE: 1"=30'



MAXIMUM SECTION

CABIN CREEK DAM
RED LION, PENNSYLVANIA
SCALE: 1" = 15'

d. Reservoir Area. The watershed is predominantly covered with woodland and farmland. The reservoir slopes are not considered to be susceptible to massive landslides which would affect storage volume of the reservoir or overtopping of the dam by displacing water.

e. Downstream Channel. Immediately below the dam is the filtration plant in which there is a man constantly on duty. Cabin Creek downstream of the dam has a very narrow, confined channel which makes at least eight (8) very sharp turns. The second structure downstream is a hunting and fishing club located .75 miles downstream. Between 1 mile and 2.6 miles downstream are several homes located near the stream. Approximately 3.4 miles downstream of the dam is a newly constructed trailer court.

3.2 Evaluation. Visual inspection did not reveal any serious signs of instability. The embankment is in need of minor maintenance particularly repairing the erosion on the downstream slope. Several seeps and wet areas were noted on the downstream slope and at the toe. No evaluation has been conducted on these areas and their effect on the stability of the embankment. Since no stability analysis has been conducted to date, it is recommended that it be conducted under conditions observed in the field.

The rock debris in the spillway exit channel has some restricting effect on the capacity of the channel. The trees growing on the exit channel highwall may cause landsliding. Visual observations indicate that the Bascule gate is in good condition. The condition of the water supply line is unknown.

SECTION 4
OPERATIONAL PROCEDURES

4.1 Procedures. The reservoir is maintained at as high a level as possible (elevation 594.0). Water is pumped into the reservoir (1 million gal/day) from an adjacent drainage area. Water is drawn out of Cabin Creek Dam on an as-needed basis (average 1.7 million gal/day). Regulation is performed with valves in the filtration plant located at the dam.

A caretaker is on duty 24 hours per day in the filtration plant. The Bascule gate is operated manually once every week.

4.2 Maintenance of the Dam. No planned maintenance schedule is utilized. All maintenance is performed on an as-needed basis. Minor work such as mowing grass is performed by borough staff. Major work is contracted. Maintenance of the dam is considered to be fair.

4.3 Maintenance of Operating Facilities. Maintenance of the operating facilities is performed by borough staff. The Bascule gate is operated on a weekly basis. The intake structure's lower gate is reportedly silted shut. Maintenance of the operating facilities is considered fair.

4.4 Warning System in Effect. There is no formal warning system in effect. The dam is maintained by borough staff stationed at the filtration plant near the dam 24 hours each day.

4.5 Evaluation. The operational procedures for the dam and appurtenant structures are considered to be fair. The dam is accessible from a country road under all weather conditions for inspection and emergency action purposes. There is no warning system to warn downstream residents of high discharges or failure of the dam.

SECTION 5
HYDRAULICS AND HYDROLOGY

5.1 Evaluation of Features.

a. Design Data. No calculations or design data pertaining to hydrology were available. Construction drawings and specifications of the existing Bascule gate were available.

b. Experience Data. The existing Bascule gate was installed in 1973. Prior to that time flashboards were installed in the spillway to maintain a maximum storage capacity in the reservoir. No reservoir level, rainfall, or runoff data are available. The dam was overtopped in 1972 causing some erosion to the embankment. The amount or depth of water going over the embankment at that time is unknown.

c. Visual Observations. The Bascule gate which controls the spillway discharge is in good condition. The gate was operated by the owner's personnel during our inspection.

Some debris was noted in the spillway exit channel. The debris was apparently from a small slide in the left slope of the channel. Maintenance should be performed on the channel slope to prevent future slides.

A low spot was noted on the dam embankment adjacent to the spillway approach wingwall. This area could easily be filled to the top of dam elevation.

d. Overtopping Potential. Overtopping potential was investigated through the development of the probable maximum flood (PMF) for the watershed and the subsequent routing of the PMF and fractions of the PMF through the reservoir and spillway. The PMF is that hypothetical flow induced by the most severe combination of precipitation, infiltration losses, and concentration of runoff at a specific location that is considered reasonably possible for a particular drainage area.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. Flood routing performed for this study is intended to provide a measure of relative spillway capacity.

To assist the engineer, and provide a standard for hydrologic analyses, the Corps of Engineers, Baltimore District, has directed that the HEC-1 Dam Safety Version systemized computer program be utilized. The program was prepared by the Hydrologic Engineering Center (HEC) U.S. Army Corps of Engineers, Davis, California, July, 1978. The major methodologies or key input data for this program are discussed briefly in Appendix D. A copy of the Users Manual should be obtained by engineers who

need more precise definitions of the computer program requirements and methodology.

5.2 Evaluation Assumptions. To enable us to complete the hydraulic and hydrologic analyses for this structure, it was necessary to make the following assumptions.

1. The Bascule gate would function properly and continue to open to a full open position in a short time period.

2. For the dam breach analysis it was assumed that dam failure would begin when the water level in the reservoir reached elevation 597.5 or 2.5 feet over the top of the dam.

3. For the overtopping analysis a top of dam elevation of 596.0 was assumed for the entire length of the crest of 220 feet. Field survey measurements taken during the inspection indicate that the top of dam elevation varies from 595.0 feet to 596.1 feet.

5.3 Summary of Overtopping Analysis. Complete summary sheets from the computer output are presented in the hydrologic appendix.

a. Spillway Adequacy Rating. The spillway design flood (SDF) for Cabin Creek Dam is the PMF. The SDF is based on the size and hazard classification of the dam. Based on the following definition provided by the Corps of Engineers, the spillway for this dam is rated as seriously inadequate.

> Seriously Inadequate - High hazard classification dams (all sizes) not capable of passing 50% of the PMF without failure where there is a significant increase in the hazard potential for loss of life downstream due to overtopping failure.

The spillway and reservoir are capable of controlling approximately 18% of the PMF without overtopping the embankment (elevation 595.0).

5.4 Summary of Dam Breach Analysis. As the subject dam cannot satisfactorily pass 50% of the PMF (based on our analysis) it was necessary to perform a breach analysis and downstream routing of the flood wave. This analysis determines the degree of increased flooding due to dam failure.

Results of the Dam Breach analysis indicate that downstream flooding is significantly increased. Therefore this spillway is rated as seriously inadequate.

The water level in the reservoir at the time of dam failure was assumed to be at 597.5' (2.5' over the top of dam) based on the evaluating engineers judgement. The 50% PMF was routed through the reservoir and downstream.

Results of routing the flood wave downstream with and without

failure are indicated in Appendix D.

The results of the floodwave routing indicate that failure due to overtopping will significantly increase downstream potential for loss of life.

Note: Future development within the watershed, at the dam, or downstream may change the characteristics and assumptions made for this study and different results are likely. Future development downstream may also greatly increase the potential for loss of life due to failure of the structure.

SECTION 6
STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability.

a. Visual Observations. Visual inspection did not reveal any signs of immediate instability. However, the erosion gullies, wet areas, and seeps, if untreated, may become more serious with time. The dam appears to conform to the constrution drawings.

b. Design and Construction Data. No record of design data or stability analysis for the original structure was available for review. There is no data on the construction of the dam.

c. Operating Records. There are no operating records. PennDER correspondence files contain considerable information on repair to the severe erosion of the downstream slope which resulted from overtopping during Tropical Storm Agnes in 1972.

d. Post-Construction Changes. There have been no post-construction changes besides installing the Bascule gate which would influence the structural stability.

e. Seismic Stability. The dam is located in seismic zone 1. No seismic stability analysis has been performed. Normally, it can be considered that if a dam in this zone is stable under static loading conditions, it can be assumed safe for any expected earthquake loading. However, the areal geology (See appendix F) indicates faulting in the area of the dam. Therefore, a more detailed geologic investigation is necessary to determine the need for seismic stability analyses.

SECTION 7
ASSESSMENT AND RECOMMENDATIONS/REMEDIAL MEASURES

7.1 Dam Assessment.

a. Safety. The visual observations, review of available information, hydrologic calculations, and past operational performance indicate that Cabin Creek Dam's spillway is seriously inadequate. The spillway is only capable of handling approximately 18% of the PMF without overtopping. No stability analysis has been performed. The long term stability of the dam is uncertain due to the seeps. Because of the seriously inadequate spillway, the dam is classified as an unsafe non-emergency dam.

b. Adequacy of Information. Assessment of the structural stability of the structure cannot be made because of the limited design data and no record of stability analyses.

c. Urgency. The recommendations suggested below should be implemented immediately.

d. Necessity for Further Investigations. In order to accomplish some of the recommendations/remedial measures outlined below, further investigations will be required.

7.2 Recommendations/Remedial Measures.

1. The owner should monitor the wet areas and seeps and take necessary remedial measures if the seeps are found to be increasing.

2. Perform additional studies by a registered professional engineer knowledgeable in dam design for modification of the spillway and/or embankment to increase spillway capacity. This study should begin immediately and remedial modifications begun immediately after the study is complete.

3. All low areas on the crest should be filled.

4. The cause of the seeps should be investigated. Piezometers should be installed to record the phreatic surface in the embankment.

5. A stability analysis of the embankment should be conducted.

6. A detailed geologic study should be made to determine if a seismic stability analysis is needed.

7. All erosion gullies should be filled.

8. The debris in the emergency spillway exit channel should be removed. Trees on the highwall should be removed.

9. Silt from the lower intake tower gate should be removed so that the intake can act as an emergency drawdown.

10. Institute a formal inspection program to be conducted at regular intervals with the borough's engineer.

11. A warning system should be instituted to warn downstream residents of high spillway discharges or failure of the dam.

CHECK LIST
VISUAL INSPECTION
PHASE I

NAME OF DAM Cabin Creek Dam COUNTY York STATE PA ID# PA 336

TYPE OF DAM Earthfill HAZARD CATEGORY High

DATE(s) INSPECTION October 31, 1978 WEATHER Sunny, mild TEMPERATURE 60's

POOL ELEVATION AT TIME OF INSPECTION 594.03 M.S.L. TAILWATER AT TIME OF INSPECTION None M.S.L.

INSPECTION PERSONNEL:

R. Jeffrey Kimball - L. Robert Kimball and Associates

James T. Hockensmith - L. Robert Kimball and Associates

Kuang hwei Chuang - L. Robert Kimball and Associates

Carl Seitz - Manager - Red Lion Water Authority

Ray Arnold - Red Lion Water Authority David Davidson - C.S. Davidson Inc. - Engineers

James T. Hockensmith RECORDER

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	None.	
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	None.	
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	Some erosion on downstream slope. Apparently from 1972 overtopping.	
VERTICAL AND HORIZONTAL ALIGNMENT OF THE CREST	Horizontal appeared all right. Low spot (1 foot) near left abutment.	
RIPRAP FAILURES	None noted.	

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
VEGETATION	Mowed grass on crest and downstream slope.	
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	No deficiencies noted except for low spot at spillway wingwall.	
ANY NOTICEABLE SEEPAGE	Seepage at several locations on downstream slope. Minimal flow noted.	
STAFF GAUGE AND RECORDER	None.	
DRAINS	End of pvc pipe noted at toe near junction of embankment and dry rubble wall. No flow noted. (near left abutment)	

CONCRETE/MASONRY DAMS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
ANY NOTICEABLE SEEPAGE	N/A	
STRUCTURE TO ABUTMENT/EMBANKMENT JUNCTIONS	N/A	
DRAINS	N/A	
WATER PASSAGES	N/A	
FOUNDATION	N/A	

CONCRETE/MASONRY DAMS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS CONCRETE SURFACES	N/A	
STRUCTURAL CRACKING	N/A	
VERTICAL AND HORIZONTAL ALIGNMENT	N/A	
MONOLITH JOINTS	N/A	
CONSTRUCTION JOINTS	N/A	
STAFF GAUGE OR RECORDER		

OUTLET WORKS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	Outlet works consists of 12" CI pipe. Unobserved.	
INTAKE STRUCTURE	Structure above water appears to be in very good condition.	
OUTLET STRUCTURE	None. 12" pipe goes in water system.	
OUTLET CHANNEL	None.	
EMERGENCY GATE	None.	

UNGATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE WEIR	N/A	
APPROACH CHANNEL	N/A	
DISCHARGE CHANNEL	N/A	
BRIDGE AND PIERS	N/A	

GATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE SILL	Appears to be in good condition.	
APPROACH CHANNEL	Appears to be in good condition.	
DISCHARGE CHANNEL	Rock cut. Rock debris in channel. Trees growing on highwall.	
BRIDGE AND PIERS	None.	
GATES AND OPERATION EQUIPMENT	Bascule gate. Appears to be in good condition and well maintained.	

DOWNSTREAM CHANNEL

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	Steep confined channel with sharp turns.	
SLOPES	Steep to moderate.	
APPROXIMATE NO. OF HOMES AND POPULATION	40 homes - 160 people for first 3.5 miles downstream.	

RESERVOIR

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES	Moderate.	
SEDIMENTATION	Sedimentation has reportedly blocked lower gate on intake tower.	

INSTRUMENTATION

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
MONUMENTATION/SURVEYS	None.	
OBSERVATION WELLS	None.	
WEIRS	None.	
PIEZOMETERS	None.	
OTHER		

APPENDIX B

CHECKLIST, ENGINEERING DATA, DESIGN, CONSTRUCTION, OPERATION, PHASE I

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
PHASE I

NAME OF DAM Cabin Creek Dam

ID# PA 336

ITEM	REMARKS
AS-BUILT DRAWINGS	None.
REGIONAL VICINITY MAP	U.S.G.S. Quadrangle - Red Lion, PA.
CONSTRUCTION HISTORY	No history available. Several photos in DER file.
TYPICAL SECTIONS OF DAM	Construction Drawings - DER file.
OUTLETS - PLAN - DETAILS - CONSTRAINTS - DISCHARGE RATINGS RAINFALL/RESERVOIR RECORDS	Construction Drawings - DER files. None. None. None.

ITEM	REMARKS
DESIGN REPORTS	None Available.
GEOLOGY REPORTS	None available.
DESIGN COMPUTATIONS HYDROLOGY & HYDRAULICS DAM STABILITY SEEPAGE STUDIES	None available.
MATERIALS INVESTIGATIONS BORING RECORDS LABORATORY FIELD	None available.
POST-CONSTRUCTION SURVEYS OF DAM	None.
BORROW SOURCES	Unknown.

ITEM	REMARKS
MONITORING SYSTEMS	None.
MODIFICATIONS	Bascule gate installed 1973.
HIGH POOL RECORDS	None.
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	None.
PRIOR ACCIDENTS OR FAILURE OF DAM DESCRIPTION REPORTS	Dam overtopped June 1972 - Correspondence in DER files.
MAINTENANCE OPERATION RECORDS	None availble.

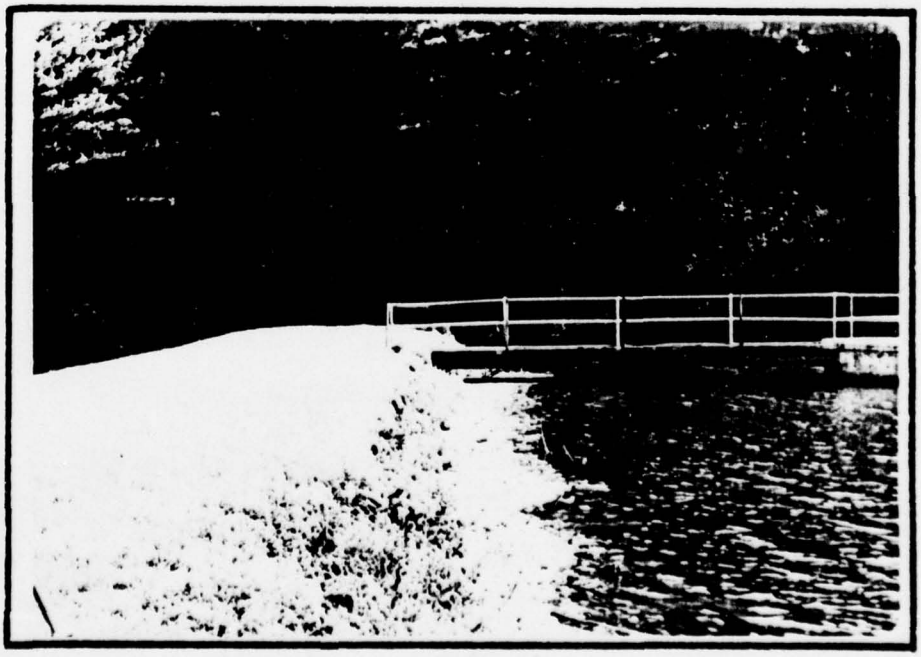
ITEM	REMARKS
SPILLWAY PLAN SECTIONS DETAILS	Construction Drawings - DER files.
OPERATING EQUIPMENT PLANS & DETAILS	Bascule gate drawing - DER files.

APPENDIX C

PHOTOGRAPHS

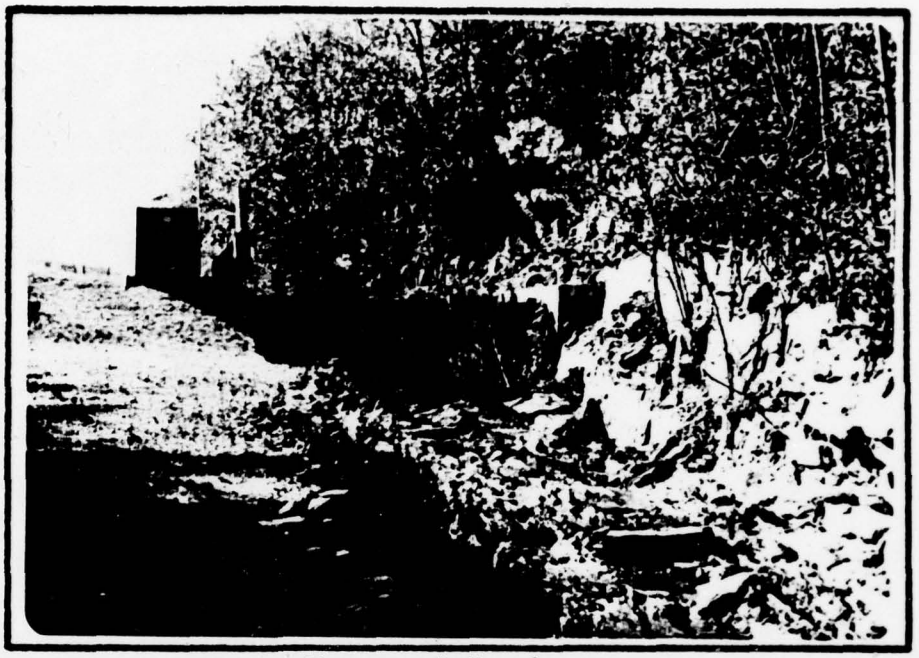
Photograph No. 1

Intake structure and spillway gate control building.



Photograph No. 2

View of upstream slope.

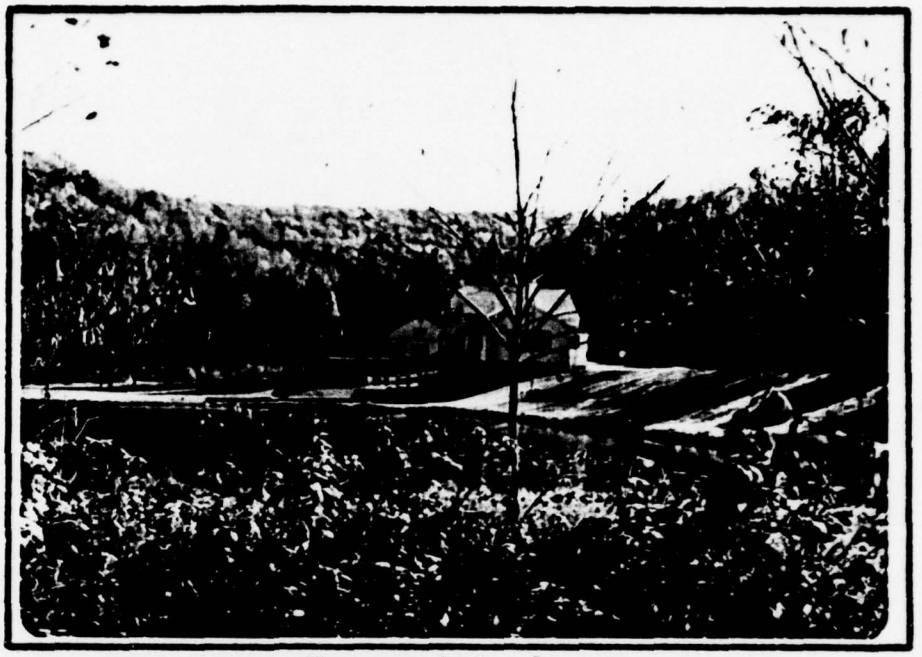


Photograph No. 3

Spillway exit channel, debris in channel and hydraulically controlled spillway.

Photograph No. 4

Looking down spillway exit channel.



Photograph No. 5

Gun Club - First downstream building.

Photograph No. 6

Mobil home park at Margaretta Furnace.

APPENDIX D

HYDROLOGY AND HYDRAULICS

APPENDIX D
HYDROLOGY AND HYDRAULICS

Methodology. The dam overtopping and breach analyses were accomplished using the systemized computer program HEC-1 (Dam Safety Version), July 1978, prepared by the Hydrologic Engineering Center, U.S. Army Corps of Engineers, Davis, California. A brief description of the methodology used in the analyses is presented below.

1. Precipitation. The Probable Maximum Precipitation (PMP) is derived and determined from regional charts prepared from past rainfall records including "Hydrometeorological Report No. 33 prepared by the National Weather Service.

The index rainfall is reduced from 10% to 20% depending on watershed size by utilization of what is termed the HOP Brook adjustment factor. Distribution of the total rainfall is made by the computer program using distribution methods developed by the Corps.

2. Inflow Hydrograph. The hydrologic analysis used in development of the overtopping potential is based on applying a hypothetical storm to a unit hydrograph to obtain the inflow hydrograph for reservoir routing.

The unit hydrograph is developed using the Snyder method. This method requires calculation of several key parameters. The following list gives these parameters their definition and how they were obtained for these analysis.

Parameter	Definition	Where Obtained
C_t	Coefficient representing variations of watershed slope and storage	From Corps of Engineers*
L	Length of main stream channel miles	From U.S.G.S. 7.5 minute topographic
L_{ca}	Length on main stream to centroid of watershed	From U.S.G.S. 7.5 minute topographic
C_p	Peaking coefficient	From Corps of Engineers*
A	Watershed size	From U.S.G.S. 7.5 minute topographic

*Developed by the Corps of Engineers on a regional basis for Pennsylvania.

3. Routing. Reservoir routing is accomplished by using Modified Plus routing techniques where the flood hydrograph is routed through reservoir storage. Hydraulic capacities of the outlet works, spillways and the crest of the dam are used as outlet controls in the routing.

The hydraulic capacity of the outlet works can either be calculated and input or sufficient dimensions input and the program will calculate an elevation discharge relationship.

Storage in the pool area is defined by an area - elevation relationship from which the computer calculates storage. Surface areas are either planimetered from available mapping or U.S.G.S. 7.5 minute series topographic maps or taken from reasonably accurate design data.

4. Dam Overtopping. Using given percentages of the PMF the computer program will calculate the percentage of the PMF which can be controlled by the reservoir and spillway without the dam overtopping.

5. Dam Breach and Downstream Routing. The computer program is equipped to determine the increase in downstream flooding due to failure of the dam caused by overtopping. This is accomplished by routing both the pre failure peak flow and the peak flow through the breach (calculated by the computer with given input assumptions) at a given point in time and determining the water depth in the downstream channel. Channel cross-sections taken from U.S.G.S. 7.5 minute topographic maps were used in the downstream flood wave routing. Pre and post failure water depths are calculated at locations where cross-sections are input.

L. ROBERT KIMBALL & ASSOCIATES
CONSULTING ENGINEERS & ARCHITECTS
EBENSBURG PENNSYLVANIA

DAM NAME Cabin Creek Dam
I.D. NUMBER PA. 67-459
SHEET NO. 1 OF 4
BY KHC DATE 1-29-79

Cabin Creek Dam

Drainage Area, $A = 2.63$ Sq. mi. (from U.S.G.S. Map)

Unit Hydrograph Parameters:

Damsite; 15A, Susquehanna River Basin

$L = 1.7$ mi., $L_{ca} = 0.8$ mi. (from U.S.G.S. Map)

$C_t = 1.15$, $C_p = 0.54$. (Rec. by COE)

$$t_p = C_t (L \cdot L_{ca})^{0.3}$$
$$= 1.15 (1.7 \times 0.8)^{0.3}$$
$$t_p = 1.26 \text{ (hr.)}$$

Loss Rate & Base Flow Parameters:
(Recommended by COE Baltimore Dist.)

Initial loss, STRTL = 1 in.

Constant loss, CNSTL = 0.05 in/hr.

Inital Flow, STRTQ = 1.5 cfs/mi.^{2}

QRCSN = 0.05 (5% of Peak Flow)

RTIOR = 2.0

Probable Maximum Storm:

PMP Index Rainfall — 23.5" from H.R. #33

R6 = 113%, R12 = 123%, R24 = 132%.
R48 = 142%

Elevation - Area - Capacity Relationships:

Initial Storage (@ El. 594) = 58 MG = 178 A-F

Surface Area = 13 Acres @ El. 594

28 Acres @ El. 600

$V = \frac{1}{3} AH$, $H = \frac{3V}{A} = \frac{3(178)}{13} = 41.08'$

Elev. of zero Capacity = 594 - 41.08 = 552.92

Elev. (ft)	552.92	594	596	598	600	602	604	606	614
Area (Acres)	0	13	17	22	28	31	33	36	49

Spillway Capacity

From specifications for Bascule Gate,

" The gate control shall start to lower the gate when the water level exceeds 6" over the top of the gate. When the water level reaches 1'-0", the gate shall be fully open. For the water levels between 6" & 12", the gate shall be positioned between open and closed so as to keep the upstream water level constant."

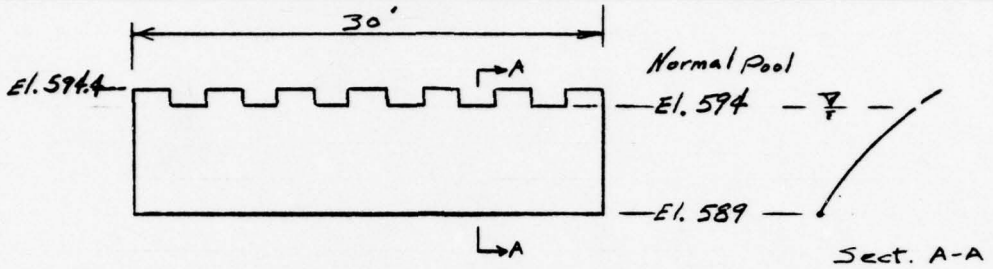
Assuming the gate will be operated properly

$Q = CLH^{1.5}$

for sharp-crested weir, use $C = 3.3$ (from Chow)

L. ROBERT KIMBALL & ASSOCIATES
CONSULTING ENGINEERS & ARCHITECTS
EBENSBURG PENNSYLVANIA

DAM NAME Cabin Creek Dam
I.D. NUMBER PA. 67-459
SHEET NO. 3 OF 4
BY KHC DATE 1-29-79



Reservoir El. (ft)	594.0	594.4	594.5		594.75	595.0	597.0	599.0	600.0
L, Weir Length (ft)	15	15	15	15	30	30	30	30	30
H (ft)	0	0.4	0.1	0.5	3	6.0	8.0	10.0	11.0
Q (cfs)	0	12.5	19.0		514	1,455	2240	3130	3610

Discharge through Dam Crest

$Q = C L H^{1.5}$

Use $C = 3.05$ (from Chow)

Crest Length, $L = 220'$

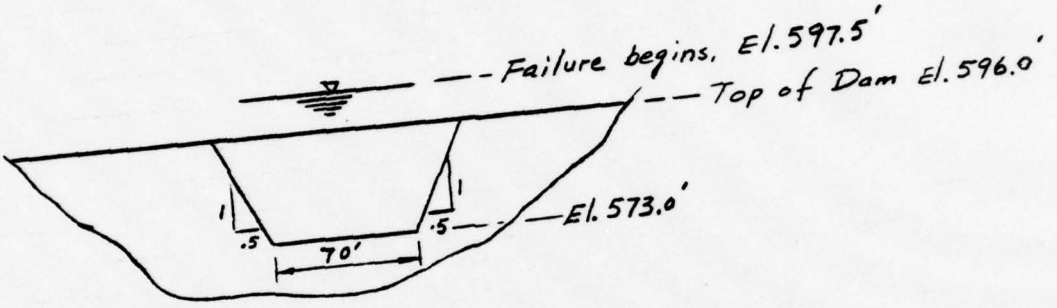
Discharge was determined with HEC-1

Top of dam Elevation = 596.0 was used in analysis.

L. ROBERT KIMBALL & ASSOCIATES
CONSULTING ENGINEERS & ARCHITECTS
EBENSBURG PENNSYLVANIA

DAM NAME Cabin Creek Dam
I.D. NUMBER PA. 67-459
SHEET NO. 4 OF 4
BY KHC DATE 1-29-79

Dam Breach Parameters:



Ratio of PMF, RTIO = 0.5

Breach width, BRWID = 70'

Side slope of breach, z = 0.5

Failure time, TFAIL = 0.5 hr.

Elevation, failure begins, FAILEL = 597.5'

Channel Routing

Channel cross sections obtained from U.S.G.S. Quad

Channel Manning's n, QN(2) = .05

Overbank Manning's n, QN(1) = QN(2) = .06

CHECK LIST
HYDROLOGIC AND HYDRAULIC
ENGINEERING DATA

DRAINAGE AREA CHARACTERISTICS: Moderate slopes, wooded and farmland

ELEVATION TOP NORMAL POOL (STORAGE CAPACITY): 594.0

ELEVATION TOP FLOOD CONTROL POOL (STORAGE CAPACITY): N/A

ELEVATION MAXIMUM DESIGN POOL: 595.0 top of dam

ELEVATION TOP DAM: 595.0

SPILLWAY CREST:

a. Elevation 589.0 (concrete sill) 594.0 (top of gate closed)
b. Type Broad crested weir and Bascule gate
c. Width -
d. Length 30'
e. Location Spillover Left abutment
f. Number and Type of Gates One - Bascule

OUTLET WORKS:

a. Type 12" CI Pipe
b. Location Through center of dam
c. Entrance inverts 580.0 and 562.0
d. Exit inverts In plant
e. Emergency draindown facilities silted shut

HYDROMETEOROLOGICAL GAUGES:

a. Type None
b. Location
c. Records

MAXIMUM NON-DAMAGING DISCHARGE: Unknown

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**********************************
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  25 SEP 78
**********************************
    1                 A1       ANALYSIS OF DAM OVERTOPPING USING RATIOS OF PMF
    2                 A2       HYDROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF CABIN CREEK DAM
    3                 A3       RATIOS OF PMF ROUTED THROUGH THE RESERVOIR  PA. 67-459
    4                 B    192       0       15        0        0        0        0        0        0        0
    5                 B1     5
    6                 J      1       5        1
    7                 J1   0.2     0.3      0.4      0.5        1
    8                 K      0       1                                    1
    9                 K1       INFLOW TO RESERVOIR
   10                 M      1       1     2.63             2.63                                       1
   11                 P             23.5     113      123      132      142
   12                 T                                                        1.0     0.05
   13                 W   1.26    0.54
   14                 X   -1.5    -.05     2.0
   15                 K      1       2                                    1
   16                 K1       ROUTE THRU RESERVOIR
   17                 Y                                1        1
   18                 Y1     1                                                -594      -1
   19                 Y4   594   594.4    594.5   594.75      595      597      599      600      602      604
   20                 Y4   606     608      610      614
   21                 Y5     0    12.5       19      514     1455     2240     3130     3610     4640     5750
   22                 Y5  6940    8200     9530    12375
   23                 $A            13       17       22       28       31       33       36       49
   24                 $E552.92     594      596      598      600      602      604      606      614
   25                 $S   594
   26                 $D   596    3.05      1.5      220
   27                 K     99
```

PREVIEW OF SEQUENCE OF STREAM NETWORK CALCULATIONS

RUNOFF HYDROGRAPH AT 1
ROUTE HYDROGRAPH TO 2
END OF NETWORK

****
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION JULY 1978
LAST MODIFICATION 25 SEP 78
****

RUN DATE 79/01/11.
TIME 15.49.53.

ANALYSIS OF DAM OVERTOPPING USING RATIOS OF PMF
HYDROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF CABIN CREEK DAM
RATIOS OF PMF ROUTED THROUGH THE RESERVOIR PA. 67-459

JOB SPECIFICATION

NQ	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
192	0	15	0	0	0	0	0	0	0

JOPER	NWT	LROPT	TRACE
5	0	0	0

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 1 NRTIO= 5 LRTIO= 1
RTIOS= .20 .30 .40 .50 1.00

********** ********** ********** ********** **********

SUB-AREA RUNOFF COMPUTATION

INFLOW TO RESERVOIR

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
1	0	0	0	0	0	1	0	0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	1	2.63	0.00	2.63	0.00	0.000	0	1	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	23.50	113.00	123.00	132.00	142.00	0.00	0.00

TRSPC COMPUTED BY THE PROGRAM IS .800

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	1.00	.05	0.00	0.00

UNIT HYDROGRAPH DATA

TP= 1.26 CP= .54 NTA= 0

RECESSION DATA

STRTQ= -1.50 QRCSN= -.05 RTIOR= 2.00

APPROXIMATE CLARK COEFFICIENTS FROM GIVEN SNYDER CP AND TP ARE TC= 5.70 AND R= 5.80 INTERVALS

UNIT HYDROGRAPH 34 END-OF-PERIOD ORDINATES, LAG= 1.26 HOURS, CP= .54 VOL= 1.00

56.	205.	407.	599.	719.	729.	646.	544.	457.	385.
324.	272.	229.	193.	162.	136.	115.	96.	81.	68.
57.	48.	41.	34.	29.	24.	20.	17.	14.	12.
10.	9.	7.	6.						

0

END-OF-PERIOD FLOW

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
									SUM	26.70	24.30	2.40	162311.
										(678.)	(617.)	(61.)	(4596.14)

HYDROGRAPH ROUTING

ROUTE THRU RESERVOIR

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
2	1	0	0	0	0	1	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	-594.	-1

STAGE	594.00	594.40	594.50	594.75	595.00	597.00	599.00	600.00	602.00
604.00									
	606.00	608.00	610.00	614.00					
FLOW	0.00	12.50	19.00	514.00	1455.00	2240.00	3130.00	3610.00	4640.00
5750.00									
	6940.00	8200.00	9530.00	12375.00					
SURFACE AREA=	0.	13.	17.	22.	28.	31.	33.	36.	49.
CAPACITY=	0.	178.	208.	247.	297.	356.	420.	489.	827.

ELEVATION=	553.	594.	596.	598.	600.	602.	604.	606.	614.

CREL	SPWID	COQW	EXPW	ELEVL	COQL	CAREA	EXPL
594.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

DAM DATA

TOPEL	COQD	EXPD	DAMWID
596.0	3.1	1.5	220.

PEAK OUTFLOW IS 1589. AT TIME 41.25 HOURS

PEAK OUTFLOW IS 2422. AT TIME 41.25 HOURS

PEAK OUTFLOW IS 3273. AT TIME 41.00 HOURS

PEAK OUTFLOW IS 4103. AT TIME 41.00 HOURS

PEAK OUTFLOW IS 8224. AT TIME 41.00 HOURS

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS RATIO 1 .20	RATIO 2 .30	RATIO 3 .40	RATIO 4 .50	RATIO 5 1.00
HYDROGRAPH AT	1	2.63	1	1654.	2481.	3308.	4136.	8271.
	(	6.81)	(	46.84)(	70.26)(	93.69)(	117.11)(	234.22)(
ROUTED TO	2	2.63	1	1589.	2422.	3273.	4103.	8224.
	(	6.81)	(	45.00)(	68.57)(	92.69)(	116.18)(	232.88)(

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	594.00	594.00	596.00
STORAGE	178.	178.	208.
OUTFLOW	0.	0.	1848.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.20	595.34	0.00	197.	1589.	0.00	41.25	0.00
.30	596.62	.62	219.	2422.	1.75	41.25	0.00
.40	597.24	1.24	231.	3273.	3.00	41.00	0.00
.50	597.74	1.74	241.	4103.	4.00	41.00	0.00
1.00	599.69	3.69	288.	8224.	6.75	41.00	0.00

```
**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  25 SEP 78
**********
    1                 A1       RATIO OF PMF ROUTED THROUGH THE RESERVOIR AND DOWNSTREAM
    2                 A2       DOWNSTREAM CONDITION DUE TO OVERTOP  CABIN CREEK DAM 67-459
    3                 A3       PLAN 1 ASSUMES BREACH. PLAN 2 ASSUMES NO BREACH
    4                 B    288        0       10        0        0        0        0        0       -4        0
    5                 B1     5
    6                 J      2        1        1
    7                 J1   .5
    8                 K      0        1                                          1
    9                 K1       INFLOW TO RESERVOIR
   10                 M      1        1    2.63             2.63                                      1
   11                 P              23.5     113      123     132      142
   12                 T                                                        1.0     0.05
   13                 W    1.26     0.54
   14                 X   -1.5     -.05     2.0
   15                 K      1        2                                          1
   16                 K1       ROUTE THRU RESERVOIR
   17                 Y                                 1        1
   18                 Y1     1                                                -594       -1
   19                 Y4   594    594.4    594.5   594.75      595      597      599      600      602      604
   20                 Y4   606      608      610      614
   21                 Y5     0     12.5       19      514     1455     2240     3130     3610     4640     5750
   22                 Y5  6940     8200     9530    12375
   23                 $A             13       17       22       28       31       33       36       49
   24                 $E552.92      594      596      598      600      602      604      606      614
   25                 $$   594
   26                 $D   596     3.05      1.5      220
   27                 $B  70.      .5      573.      .5      594.     597.5
   28                 $B  70.      .5      573.      5.      594.     599.
   29                 K      1        3                                          1
   30                 K1       CHANNEL ROUTING -MOD PULS REACH 2-3
   31                 Y                                    1        1
   32                 Y1     1
```

```
Y6  .06   .05    .06    490.   540.   4000.  .0225
Y7        540.   100.   520.   160.   500.   345.   490.   350.   490.
Y7 450.   500.   460.   520.   465.   540.
K      1          4                              1
K1       CHANNEL ROUTING -MOD PULS REACH 3-4
Y                                    1      1
Y1     1
Y6  .06   .05    .06    410.   460.   5300.  .0151
Y7        500.   275.   460.   440.   420.   545.   410.   550.   410.
Y7 650.   420.   800.   460.   1025.  500.
K      1          5                              1
K1       CHANNEL ROUTING -MOD PULS REACH 4-5
Y                                    1      1
Y1     1
Y6  .06   .05    .06    380.   410.   3400.  .0088
Y7        420.   175.   400.   240.   390.   325.   380.   525.   380.
Y7 610.   390.   675.   400.   700.   420.
K      1          6                              1
```

```
51          K1      CHANNEL ROUTING -MOD PULS REACH 5-6
52          Y                                       1       1
53          Y1    1
54          Y6  .06    .05     .06     360.    400.    5300.   .0038
55          Y7         400.    150.    380.    350.    370.    550.    360.    700.    360.
56          Y7 810.    370.    950.    380.    1000.   400.
57          K     99
```

PREVIEW OF SEQUENCE OF STREAM NETWORK CALCULATIONS

RUNOFF HYDROGRAPH AT	1
ROUTE HYDROGRAPH TO	2
ROUTE HYDROGRAPH TO	3
ROUTE HYDROGRAPH TO	4
ROUTE HYDROGRAPH TO	5
ROUTE HYDROGRAPH TO	6
END OF NETWORK	

****
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION JULY 1978
LAST MODIFICATION 25 SEP 78
****

RUN DATE 79/01/12.
TIME 12.38.35.

RATIO OF PMF ROUTED THROUGH THE RESERVOIR AND DOWNSTREAM
DOWNSTREAM CONDITION DUE TO OVERTOP CABIN CREEK DAM 67-459
PLAN 1 ASSUMES BREACH. PLAN 2 ASSUMES NO BREACH

JOB SPECIFICATION

NQ	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
288	0	10	0	0	0	0	0	-4	0
			JOPER	NWT	LROPT	TRACE			
			5	0	0	0			

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 2 NRTIO= 1 LRTIO= 1

RTIOS= .50

********** ********** ********** ********** **********

SUB-AREA RUNOFF COMPUTATION

INFLOW TO RESERVOIR

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
1	0	0	0	0	0	1	0	0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	1	2.63	0.00	2.63	0.00	0.000	0	1	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	23.50	113.00	123.00	132.00	142.00	0.00	0.00

TRSPC COMPUTED BY THE PROGRAM IS .800

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	1.00	.05	0.00	0.00

UNIT HYDROGRAPH DATA

TP= 1.26 CP= .54 NTA= 0

RECESSION DATA

STRTQ= -1.50 QRCSN= -.05 RTIOR= 2.00

UNIT HYDROGRAPH 53 END-OF-PERIOD ORDINATES, LAG= 1.27 HOURS, CP= .54 VOL= 1.00

31.	117.	236.	374.	514.	630.	706.	737.	707.	638.
572.	512.	459.	411.	368.	330.	295.	265.	237.	212.
190.	170.	153.	137.	123.	110.	98.	88.	79.	71.
63.	57.	51.	46.	41.	37.	33.	29.	26.	24.
21.	19.	17.	15.	14.	12.	11.	10.	9.	8.
7.	6.	6.							

D=10

0 END-OF-PERIOD FLOW

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
									SUM	26.70	24.29	2.40	243000.
										(678.)(617.)(61.)(6880.99)			

********** ********** ********** ********** **********

HYDROGRAPH ROUTING

ROUTE THRU RESERVOIR

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
2	1	0	0	0	0	1	0	0

ALL PLANS HAVE SAME ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	-594.	-1

STAGE	594.00	594.40	594.50	594.75	595.00	597.00	599.00	600.00	602.00
604.00									
	606.00	608.00	610.00	614.00					
FLOW	0.00	12.50	19.00	514.00	1455.00	2240.00	3130.00	3610.00	4640.00
5750.00									
	6940.00	8200.00	9530.00	12375.00					
SURFACE AREA=	0.	13.	17.	22.	28.	31.	33.	36.	49.
CAPACITY=	0.	178.	208.	247.	297.	356.	420.	489.	827.
ELEVATION=	553.	594.	596.	598.	600.	602.	604.	606.	614.

CREL	SPWID	COQW	EXPW	ELEVL	COQL	CAREA	EXPL
594.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

DAM DATA

TOPEL	COQD	EXPD	DAMWID
596.0	3.1	1.5	220.

DAM BREACH DATA

BRWID	Z	ELBM	TFAIL	WSEL	FAILEL
70.	.50	573.00	.50	594.00	597.50

BEGIN DAM FAILURE AT 40.67 HOURS

PEAK OUTFLOW IS 9662. AT TIME 41.08 HOURS

OVN

DAM BREACH DATA

BRWID	Z	ELBM	TFAIL	WSEL	FAILEL
70.	.50	573.00	5.00	594.00	599.00

PEAK OUTFLOW IS 40694 AT TIME 41.00 HOURS

********** ********** ********** ********** **********

HYDROGRAPH ROUTING

CHANNEL ROUTING -MOD PULS REACH 2-3

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
3	1	0	0	0	0	1	0	0

ALL PLANS HAVE SAME ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	0.	0

NORMAL DEPTH CHANNEL ROUTING

QN(1)	QN(2)	QN(3)	ELNVT	ELMAX	RLNTH	SEL
.0600	.0500	.0600	490.0	540.0	4000.	.02250

CROSS SECTION COORDINATES--STA,ELEV,STA,ELEV--ETC

0.00 540.00 100.00 520.00 160.00 500.00 345.00 490.00 350.00 490.00
450.00 500.00 460.00 520.00 465.00 540.00

STORAGE	0.00	10.27	38.66	85.18	149.51	221.14	295.00	371.09	449.41
529.95									
	612.71	697.70	785.12	875.79	969.79	1067.14	1167.82	1271.84	1379.20
1489.90									
OUTFLOW	0.00	624.01	3657.85	10487.82	22937.63	43615.91	69486.58	100231.10	135638.28
175560.24									
	219889.93	268548.37	321193.66	378043.87	439326.33	505059.17	575270.90	649996.38	729274.78
813148.35									
STAGE	490.00	492.63	495.26	497.89	500.53	503.16	505.79	508.42	511.05
513.68									
	516.32	518.95	521.58	524.21	526.84	529.47	532.11	534.74	537.37
540.00									
FLOW	0.00	624.01	3657.85	10487.82	22937.63	43615.91	69486.58	100231.10	135638.28
175560.24									
	219889.93	268548.37	321193.66	378043.87	439326.33	505059.17	575270.90	649996.38	729274.78
813148.35									

MAXIMUM STAGE IS 497.4

MAXIMUM STAGE IS 495.4

********** ********** ********** ********** **********

HYDROGRAPH ROUTING

CHANNEL ROUTING -MOD PULS REACH 3-4

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO

4	1	0	0	0	0	1	0	0

ALL PLANS HAVE SAME

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP		LSTR
0.0	0.000	0.00	1	1	0	0		0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.004	0.	0

NORMAL DEPTH CHANNEL ROUTING

QN(1)	QN(2)	QN(3)	ELNVT	ELMAX	RLNTH	SEL
.0600	.0500	.0600	410.0	460.0	5300.	.01510

CROSS SECTION COORDINATES--STA,ELEV,STA,ELEV--ETC

0.00 900.00 275.00 460.00 440.00 420.00 545.00 410.00 550.00 410.00
650.00 420.00 800.00 460.00 1925.00 500.00

STORAGE	0.00	10.24	37.75	82.53	144.38	216.26	294.78	379.94	471.73
570.15									
	675.21	786.91	905.24	1030.21	1161.82	1300.05	1444.93	1596.44	1754.58
1919.36									
OUTFLOW	0.00	389.48	2222.26	6308.10	13722.92	26122.88	41934.48	61144.50	83775.63
109872.67									
	139494.11	172707.34	209585.66	250206.38	294649.52	342997.02	395332.04	451738.58	512301.12
577104.43									
STAGE	410.00	412.63	415.26	417.89	420.53	423.16	425.79	428.42	431.05

433.68	436.32	438.95	441.58	444.21	446.84	449.47	452.11	454.74	457.37
460.00									
FLOW	0.00	389.48	2222.26	6308.10	13722.92	26122.88	41934.48	61144.50	83775.63
109872.67	139494.11	172707.34	209585.66	250206.38	294649.52	342997.02	395332.04	451738.58	512301.12
577104.43									

MAXIMUM STAGE IS 418.7

MAXIMUM STAGE IS 416.4

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HYDROGRAPH ROUTING

CHANNEL ROUTING -MOD PULS REACH 4-5

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
5	1	0	0	0	0	1	0	0

ALL PLANS HAVE SAME ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	0.	0

NORMAL DEPTH CHANNEL ROUTING

QN(1)	QN(2)	QN(3)	ELNVT	ELMAX	RLNTH	SEL
.0600	.0500	.0600	380.0	410.0	3400.	.00880

CROSS SECTION COORDINATES--STA,ELEV,STA,ELEV--ETC

0.00 420.00 175.00 400.00 240.00 390.00 325.00 380.00 525.00 380.00
610.00 390.00 675.00 400.00 700.00 420.00

STORAGE	0.00	26.30	55.91	88.83	125.06	164.59	207.44	253.41	301.96
353.05									
	406.66	462.80	521.46	582.63	645.87	711.06	778.20	847.28	918.30
991.28									
OUTFLOW	0.00	1225.78	3996.76	8082.20	13443.84	20091.40	28054.90	38399.06	50731.93
64577.07									
	79947.65	96857.50	115322.10	135390.91	157108.00	180403.03	205273.13	231719.79	259747.42
289362.56									
STAGE	380.00	381.58	383.16	384.74	386.32	387.89	389.47	391.05	392.63
394.21									
	395.79	397.37	398.95	400.53	402.11	403.68	405.26	406.84	408.42
410.00									
FLOW	0.00	1225.78	3996.76	8082.20	13443.84	20091.40	28054.90	38399.06	50731.93
64577.07									
	79947.65	96857.50	115322.10	135390.91	157108.00	180403.03	205273.13	231719.79	259747.42
289362.56									

MAXIMUM STAGE IS 384.7

MAXIMUM STAGE IS 383.1

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HYDROGRAPH ROUTING

CHANNEL ROUTING -MOD PULS REACH 5-6

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
6	1	0	0	0	0	1	0	0

ALL PLANS HAVE SAME ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.009	0.	0

NORMAL DEPTH CHANNEL ROUTING

QN(1)	QN(2)	QN(3)	ELNVT	ELMAX	RLNTH	SEL
.0600	.0500	.0600	360.0	400.0	5300.	.00280

CROSS SECTION COORDINATES--STA,ELEV,STA,ELEV--ETC

0.00 400.00 150.00 380.00 350.00 370.00 550.00 360.00 700.00 360.00
810.00 370.00 950.00 380.00 1900.00 400.00

STORAGE	0.00	46.78	110.28	190.49	287.43	401.13	532.71	682.62	850.87
1037.46									
	1240.76	1451.07	1666.78	1887.88	2114.37	2346.25	2583.53	2826.19	3074.26
3327.71									
OUTFLOW	0.00	1039.28	3636.33	7864.78	13909.97	22439.19	34698.68	49548.47	67155.87

87672.38 111599.32 138877.23 169024.15 201970.95 237670.52 276090.44 317208.69 361010.98 407488.90
456638.65

STAGE	360.00	362.11	364.21	366.32	368.42	370.53	372.63	374.74	376.84
378.95									
	381.05	383.16	385.26	387.37	389.47	391.58	393.68	395.79	397.89
400.00									
FLOW	0.00	1039.28	3636.33	7864.78	13909.97	22439.19	34698.68	49548.47	67155.87
87672.38									
	111599.32	138877.23	169024.15	201970.95	237670.52	276090.44	317208.69	361010.98	407488.90
456638.65									

MAXIMUM STAGE IS 365.8

MAXIMUM STAGE IS 364.3

********** ********** ********** ********** **********

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIO APPLIED TO FLOWS 1 .50
HYDROGRAPH AT	1	2.63	1	4115.
	(	6.81)	(	116.53)(
			2	4115.
			(	116.53)(
ROUTED TO	2	2.63	1	9185.
	(	6.81)	(	260.08)(
			2	4065.
			(	115.11)(
ROUTED TO	3	2.63	1	9148.
	(	6.81)	(	259.05)(
			2	4038.
			(	114.35)(
ROUTED TO	4	2.63	1	8461.
	(	6.81)	(	239.60)(
			2	4007.
			(	113.47)(
ROUTED TO	5	2.63	1	8061.
	(	6.81)	(	228.25)(
			2	3981.
			(	112.72)(

ROUTED TO	6	2.63	1	6908.
	(	6.81)	(	195.62)(
			2	3874.
			(	109.70)(

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 ••••••••••••••••

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	594.00	594.00	596.00
STORAGE	178.	178.	208.
OUTFLOW	0.	0.	1848.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.50	597.58	1.58	238.	9662.	1.35	41.08	40.67

PLAN 2 ••••••••••••••••

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	594.00	594.00	596.00
STORAGE	178.	178.	208.
OUTFLOW	0.	0.	1848.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.50	597.72	1.72	241.	4065.	4.00	41.00	0.00

PLAN 1 STATION 3

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.50	9148.	497.4	41.17

PLAN 2 STATION 3

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.50	4038.	495.4	41.17

PLAN 1 STATION 4

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.50	8461.	418.7	41.17

PLAN 2 STATION 4

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.50	4007.	416.4	41.17

PLAN 1 STATION 5

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.50	8061.	384.7	41.33

PLAN 2 STATION 5

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.50	3981.	383.1	41.33

PLAN 1 STATION 6

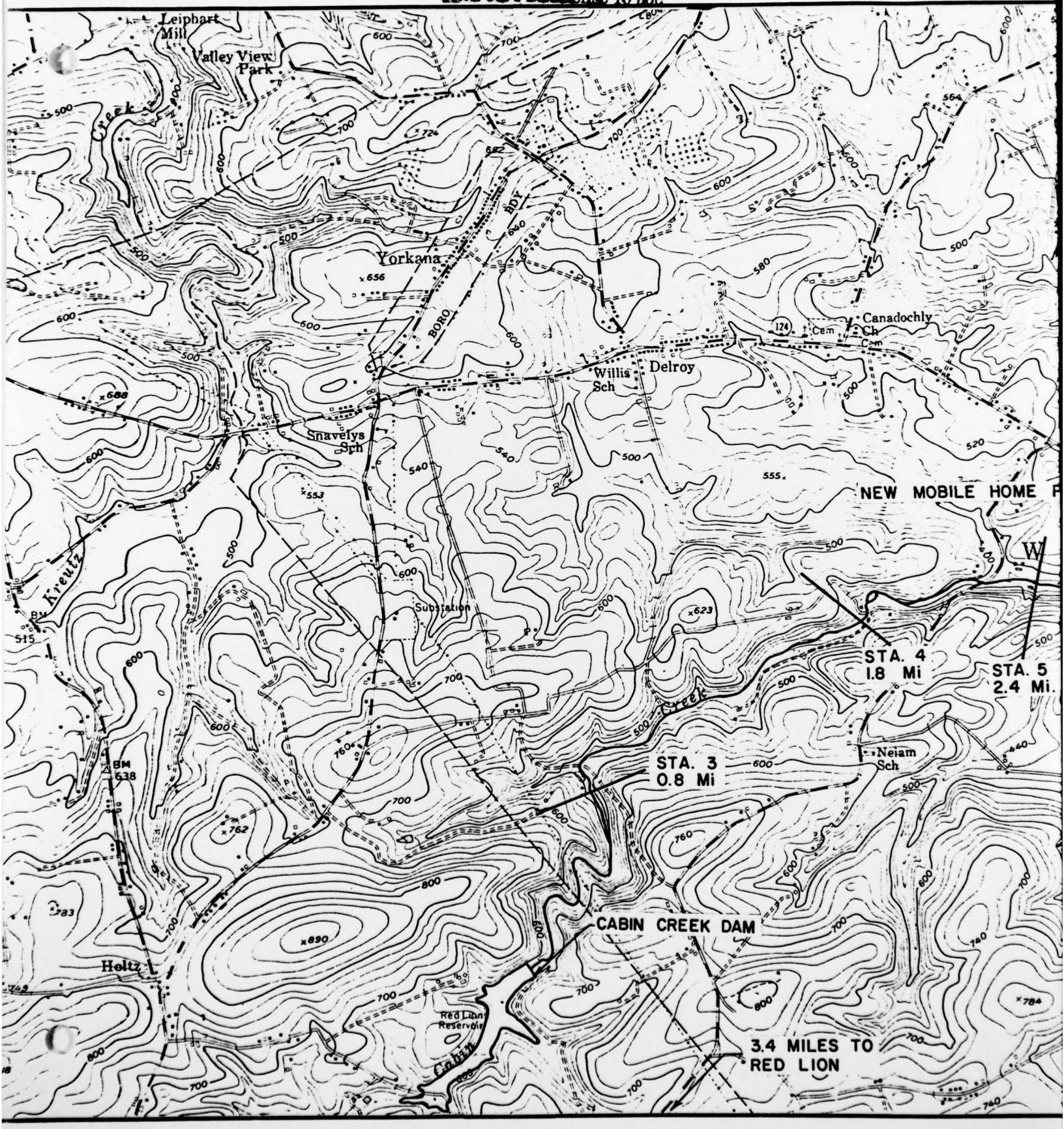
RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.50	6908.	365.8	41.50

PLAN 2 STATION 6

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.50	3874.	364.3	41.67

APPENDIX E

DRAWINGS



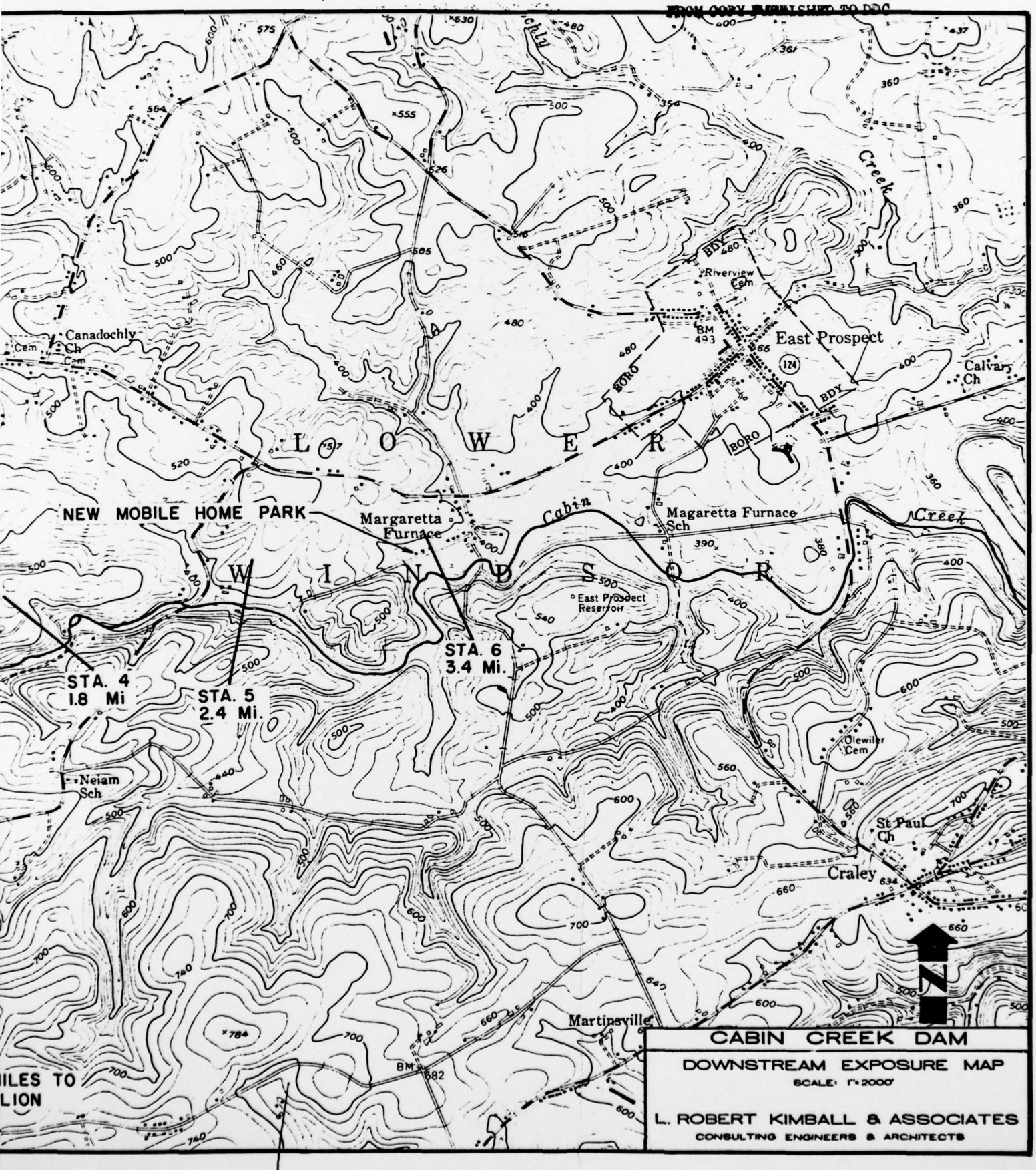
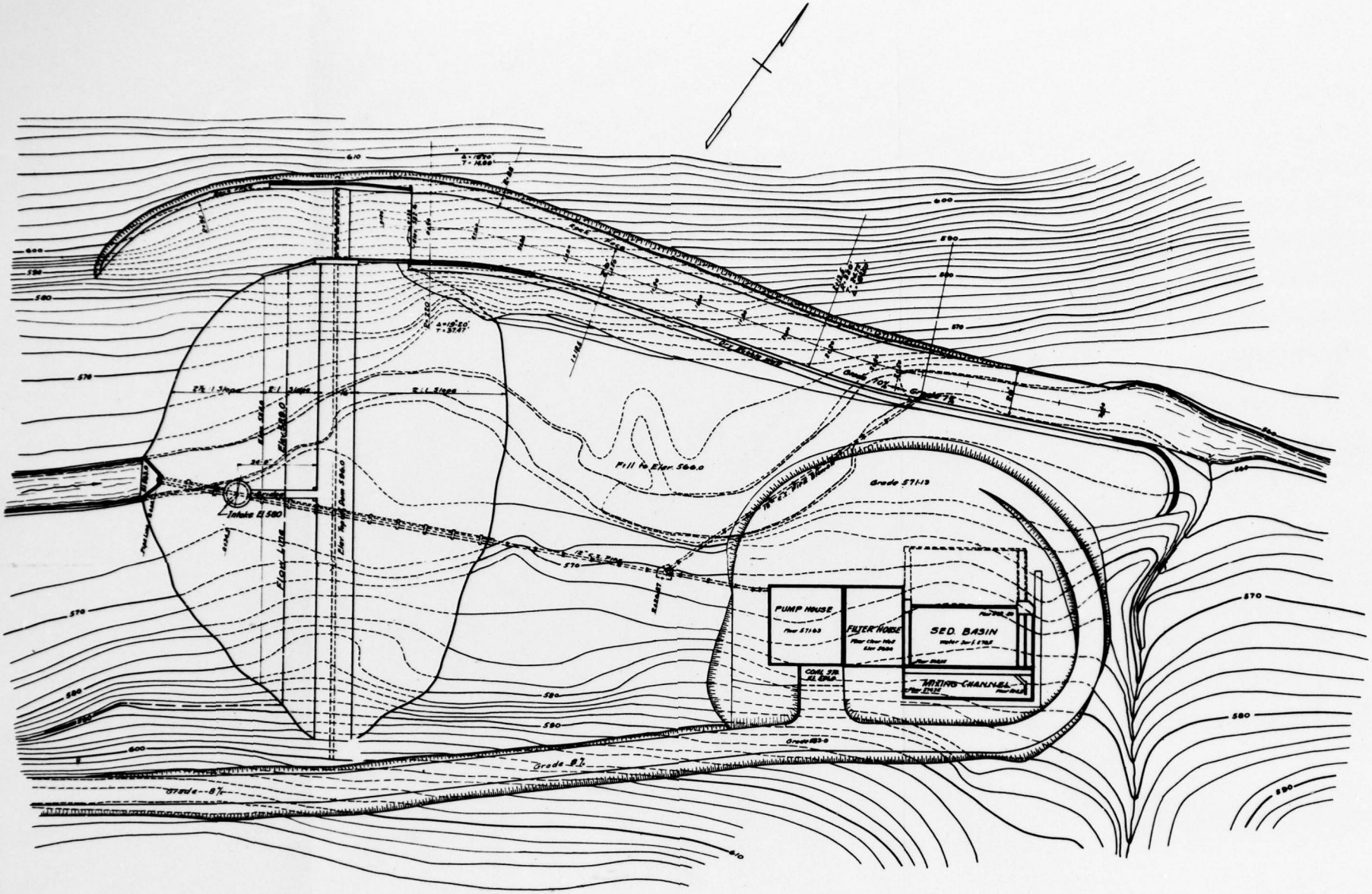
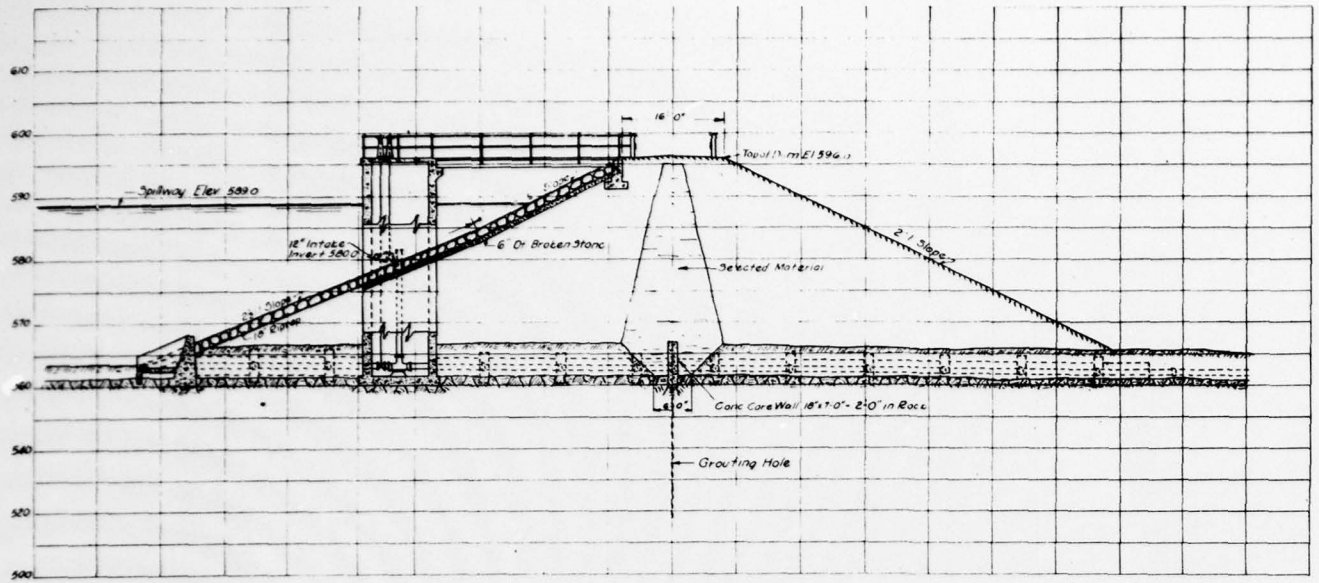


FIGURE 1



RED LION WATER CO
RED LION, PA.
CABIN CREEK DAM
GENERAL PLAN SHOWING TOPOGRAPHY
Scale: 1"=20' May 1925
Gannett, Seelye & Fleming
Engineers, Inc.
Harrisburg, Pa. Memphis, Tenn

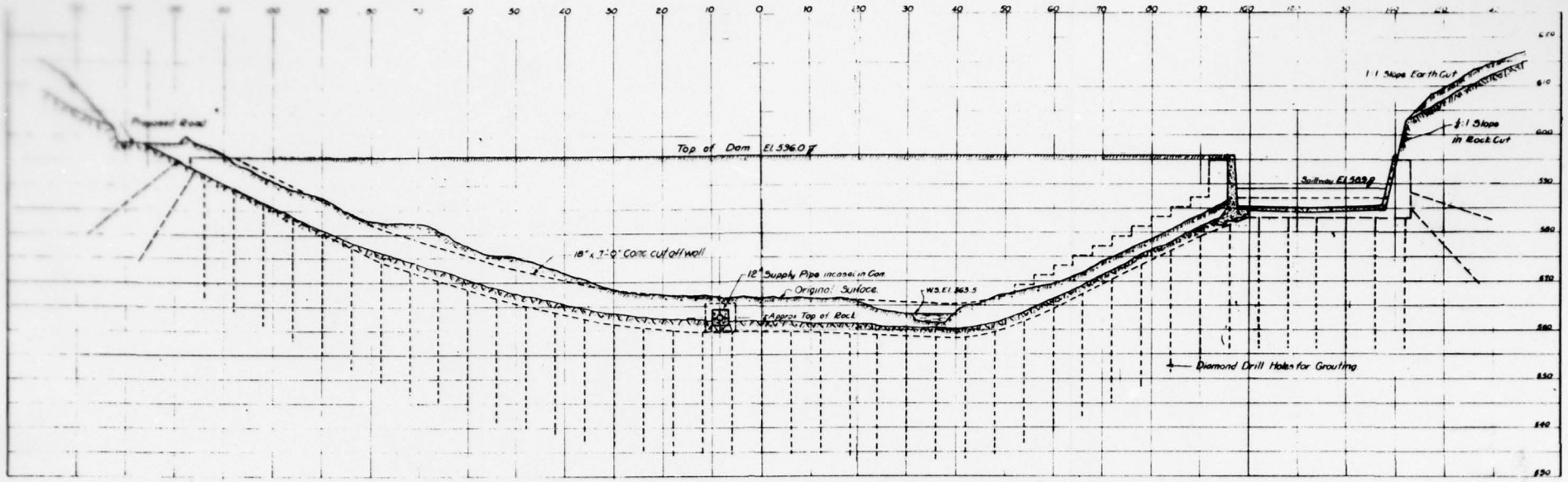


RED LION WATER CO.
RED LION, PA.
CABIN CREEK DAM
CROSS SECTION OF DAM

Scale: 1"=10'-0" Hor & Vert May, 1925.

Gannett, Seelye & Fleming
Engineers, Inc.
Harrisburg, Pa. Memphis, Tenn.

L. ROBERT KIMBALL & ASSOCIATES
CONSULTING ENGINEERS & ARCHITECTS



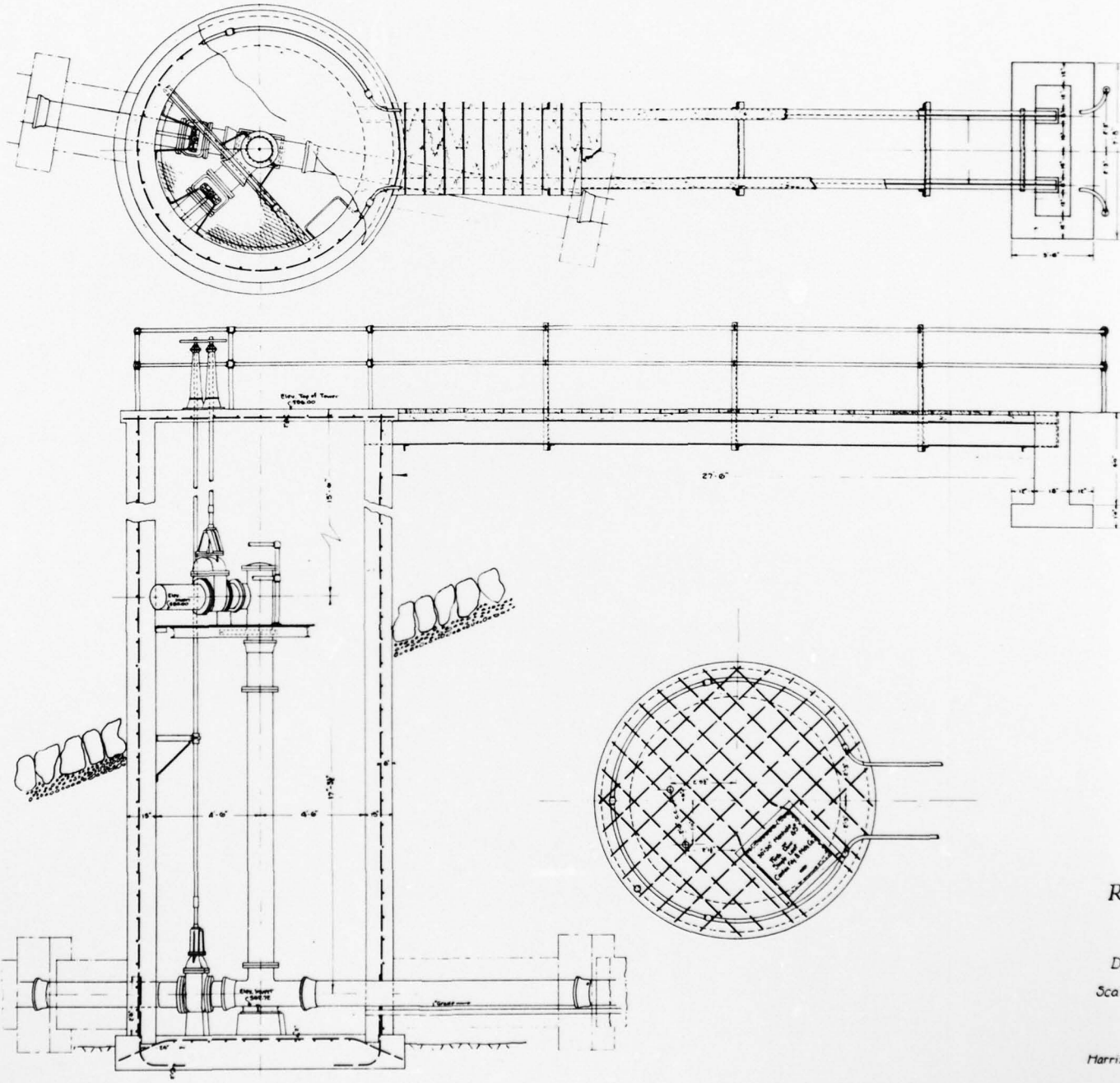
LONGITUDINAL SECTION
EAST EDGE OF TOP OF DAM
Scale 1"-10'-0" Hor & Vert

RED LION WATER CO.
RED LION, PA.
CABIN CREEK DAM

LONGITUDINAL SEC & DETAILS

Scale-1"-10'-0" May 1925

Gannett, Seelye & Fleming
Engineers, Inc.
Harrisburg, Pa Memphis, Tenn.



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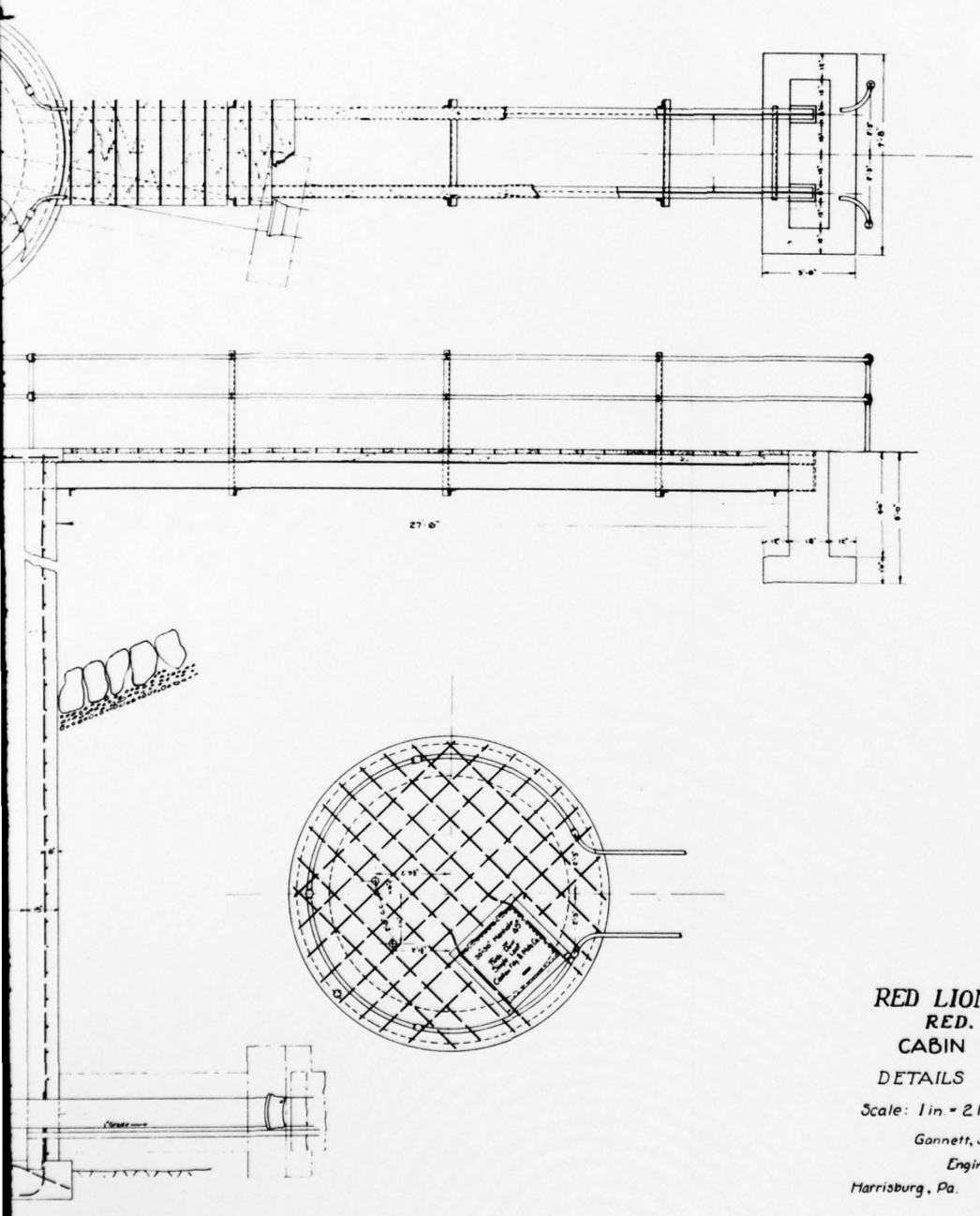
L. ROBERT K

CONSULTING



RED LION WATER CO.
RED. LION, PA
CABIN CREEK DAM
DETAILS OF GATE TOWER
Scale: 1 in. = 2 Ft. May, 1923
Gannett, Seelye & Fleming
Engineers, Inc.
Harrisburg, Pa. Memphis, Tenn.

2

1

L. ROBERT KIMBALL & ASSOCIATES
CONSULTING ENGINEERS & ARCHITECTS

FIGURE 5

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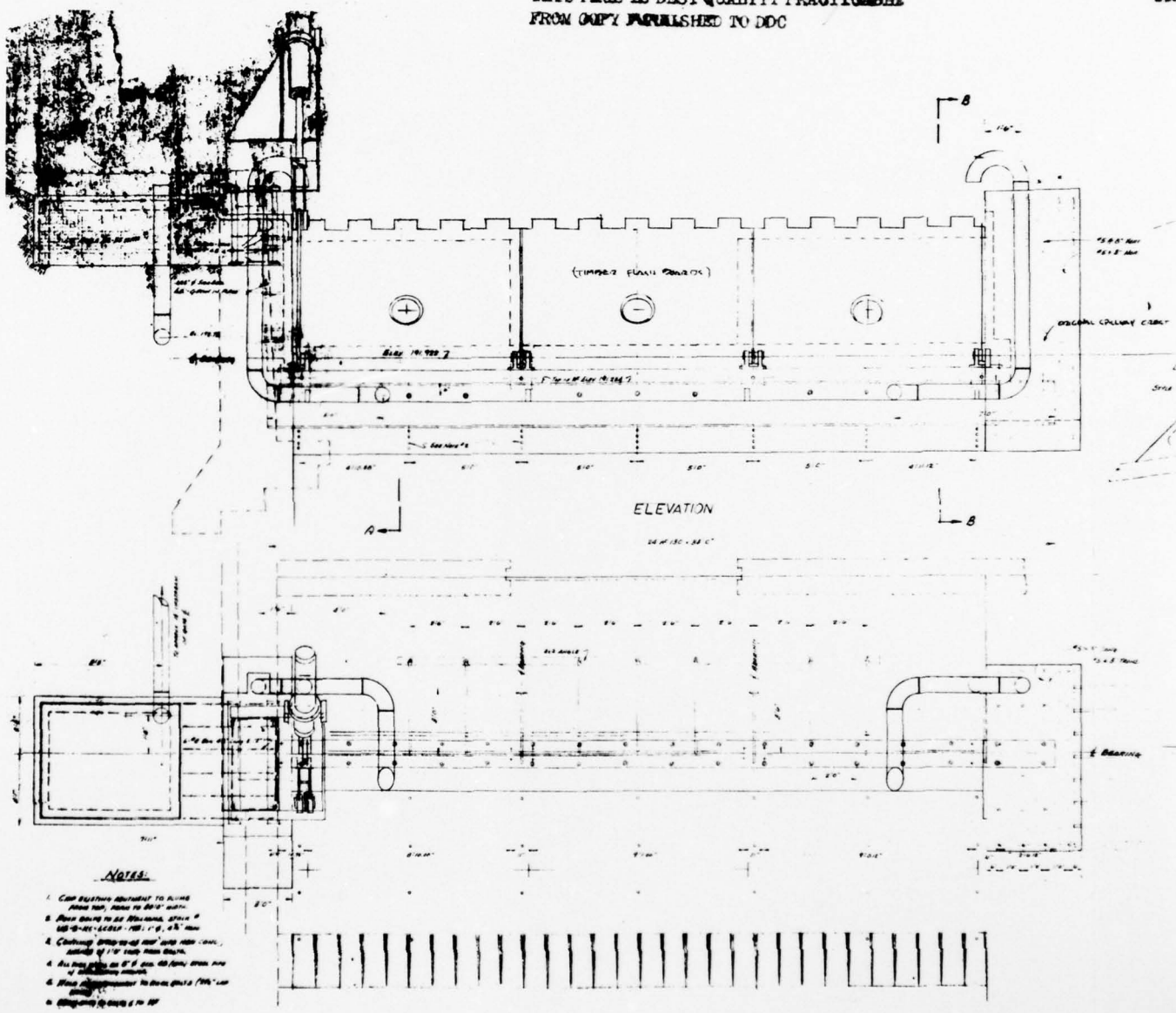

Revised 8-29-74
Revised 9-26-73 - Foundation Details

L. ROBE
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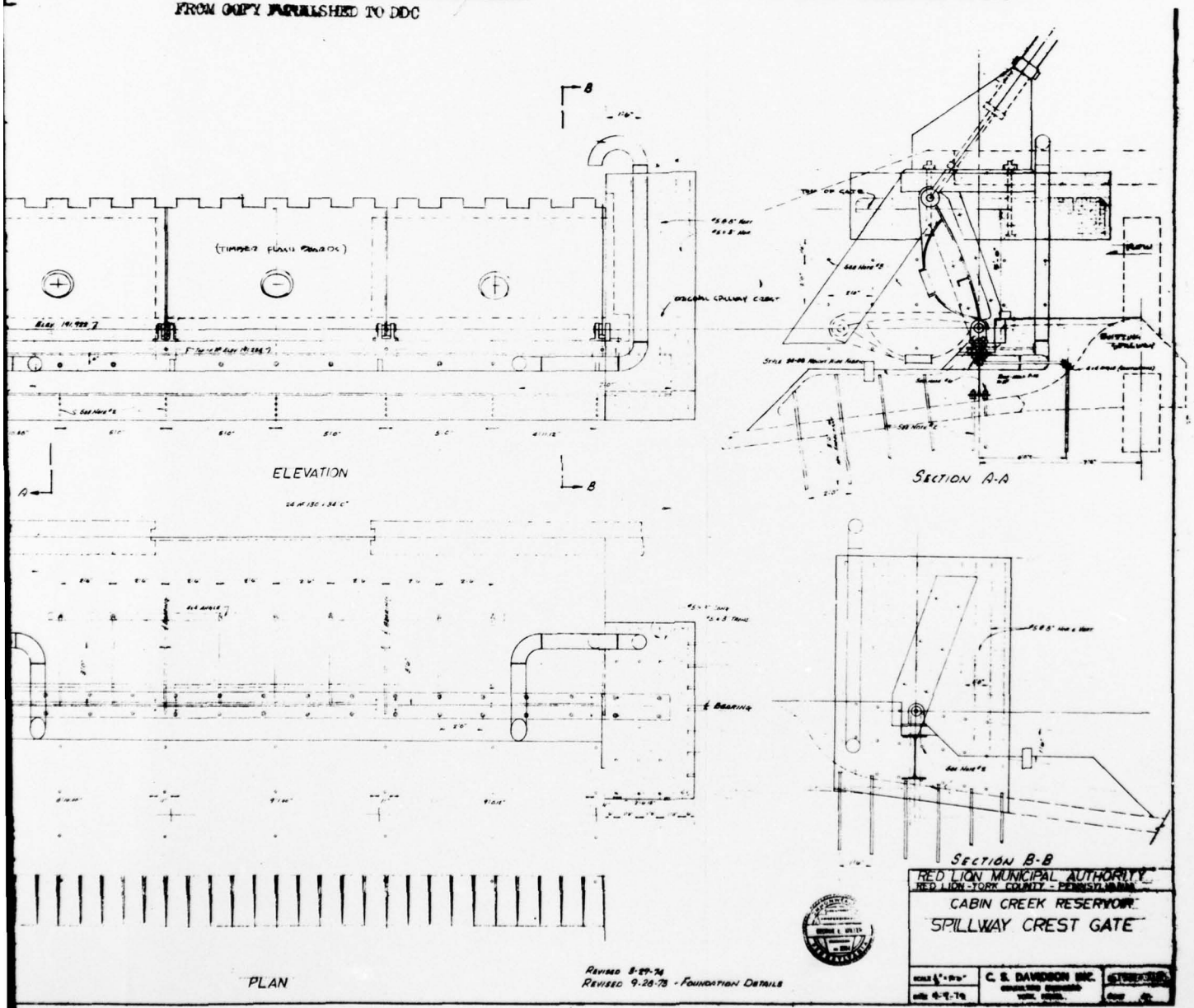


Revised 5-29-74
Revised 9-28-78 - Foundation Details

RED LION MUNICIPAL AUTHORITY
RED LION-YORK COUNTY - PENNSYLVANIA
CABIN CREEK RESERVOIR
SPILLWAY CREST GATE

C. S. DAVIDSON INC.

L. ROBERT KIMBALL & ASSOCIATES
CONSULTING ENGINEERS & ARCHITECTS

FIGURE 6

APPENDIX F

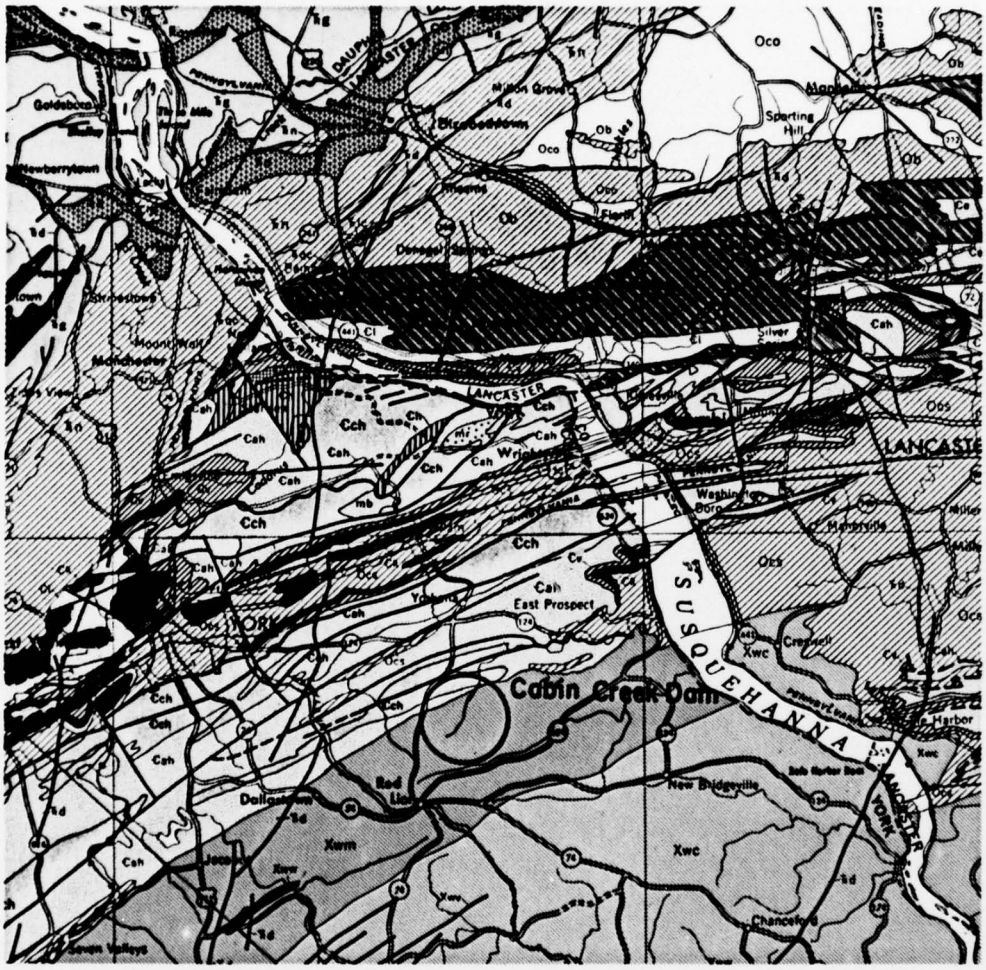
GEOLOGY

General Geology.

The Red Lion Reservoir and Cabin Creek Dam lie within the Triassic Lowland Section of the Piedmont Physiographic Province. This area is structurally complex with a great deal of faulting and folding. The Red Lion Reservoir and dam straddle three different rock types. The bedrock consists primarily of the lower Paleozoic Marburg Schist (Xwm) with an east-west trending lens of quartzite. This gray-green schist is composed of mostly chlorite, quartzite and mica. It is fissile, thin and has a well developed platy cleavage. Joints are present, but are usually irregular and poorly formed. The schist is moderately resistant to weathering, but may be highly weathered in some localities. This material has formed a good foundation for heavy structures if excavated beyond the weathered zone. It has good surface drainage and a low secondary porosity from the joints and cleavage.

The Cambrian aged Harper's Phyllite (Ch) is the other rock type and is present under the northern portion of the reservoir. It is a dark greenish-gray, fissile, and moderately well bedded with joint and cleavage planes showing a seamy pattern. They are abundant and closely spaced, but irregularly distributed. The phyllite may be highly and deeply weathered and should be excavated to sound material if it is to serve as a foundation for heavy structures. It has a low secondary porosity from the joints and cleavage planes.

The phyllite and schist are separated by the Martic Overthrust Fault which appears to pass directly under the dam. This is an ancient fault and should no longer have any potential for movement. Another smaller fault passes within a half mile of the northeastern edge of the reservoir, but nothing is known of its displacement or activity.



Geologic Map of Cabin Creek Dam Area

Wissahickon Formation

Albite chlorite schist (Xw)
Includes Octoraro Phyllite and some hornblende gneiss and granitized members.

Marburg Schist (Xam)
Gray green, mica chlorite quartzite schist, mapped west of Susquehanna River only.

Wakefield Marble (Xwc)
Light gray coarse crystalline marble.

Metavolcanics (Xmv)
Altered basaltic flows, some amygdaloidal, green, schistose with hornblende, epidote, chlorite and quartz.

Scale: 1:250,000

Antietam Formation
Gray, buff weathering quartzite and quartz schist.

Harpers Formation
Dark greenish gray phyllite and schist with thin quartzite layers; includes Montalto Member Cms, gray quartzite.